KNOWLEDGE
AN ILLUSTRATED MAGAZINE OF SCIENCE, LITERATURE & ART.

Founded in 1881 by RICHARD A. PROCTOR.

LONDON: FEBRUARY 1, 1898.

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THE FLOOR OF A CONTINENT.

By GRENVILLE A. J. COLE, M.R.I.A., F.G.S., *Professor of Geology in the Royal College of Science for Ireland.*

WHEN we consider the thickness of the sedimentary deposits that lie beneath us at any point on the surface of the earth, and compare them with the depth of four thousand miles that separates us from the earth's centre, we may come to regard the whole stratified series as a mere blanket on the true substance of the globe. Ever since the crust became solid—ever since the atmosphere cooled and the rain began to fall—the earth's surface has been subject to denudation, and the dust and mud of it have been carried into the shallow depressions that have formed in it from time to time. Wrinklings of the crust have uplifted these layers of earth-dust, and have folded them, together with more fundamental matter, into mountains and continental margins. In the sections thus revealed, the sweepings of the earth—the sedimentary series—assume to our eyes magnificent proportions; but every now and then we have a glimpse of the real body of the earth (or, rather, of its real skin), cleaned from this dust of ages. In no spot on the globe have all the stratified rocks that are known to us been piled continuously one upon another; but, even if this had been the case, they would have formed a layer less than twenty-five miles thick. If we represent the earth's radius by ten inches, this layer would appear, on the same scale, as less than one-sixteenth of an inch.

Where, indeed, denudation has long been active, as in the northern regions of Europe and America, we find ourselves in the presence of a vast bared surface, in which there is little to remind us of the sediments of ordinary geological periods. Here and there, isolated relics, like the marine Jurassic beds of the island of Andö, suggest to us the coating of stratified rocks that once spread over much of this denuded area; but the main masses are of Pre-Cambrian age—that is, they underlie the beds that contain the oldest clearly recorded fauna on the globe. Here, then, we seem to be in touch with the true substance of the crust—with the floor on which our filmy continental or oceanic accumulations rest.

Without entering into microscopic details, we may see that there is a remarkable uniformity of character in the rocks that form this floor. Gneisses, resembling granites, but with a "streaked out" and even banded arrangement of their constituents, form the largest portion of the mass. Their chemical composition* almost always shows a high percentage of silica, and the alkalies amount to five or even eight per cent. Their essential structure, the "foliated" arrangement of their mineral constituents, may have been induced in them by pressure after they had become practically solid, or by the flow of the whole mass while the crystals were still in course of construction. The larger constituents thus possess a lenticular form, as if drawn out at their edges; and these lenses lie in similar positions throughout considerable masses of the rock. The smaller constituents seem to have flowed round about them, streaming on in fairly parallel layers; and thus "foliation-planes" have been set up, along which even coarse-grained gneisses tend to split when struck.

In many gneisses there are distinct rock-bands, some bands, for instance, resembling mica-schist, while others resemble fine-grained granite, rich in quartz and felspar (Fig. 1). In such cases it is quite possible that one type of rock has intruded into another in fine parallel sheets,† or that a viscid mass of varied composition has been pressed out underground, and so has received a gneissic structure.‡

Sometimes above the typical gneisses, and sometimes associated with them, there is usually a series of crystalline rocks of much finer grain and of greater variety of composition. Foliation is present in them, and they are classed collectively as schists. Mica-schist, a foliated mixture of quartz and mica (usually muscovite), and commonly accompanied by red-brown garnet, is the type most extensively developed. The schists present many analogies with sedimentary rocks, and many mica-schists have undoubtedly arisen from the extreme alteration of sediments under heat and pressure; but the planes of foliation only rarely correspond to those of original deposition, and the crystalline character of the constituents

* See, for instance, Roth, "Allgemeine und chem. Geologie," Bd. II., p. 397.

† Compare A. C. Lawson, "A Multiple Diabase Dyke," *American Geologist*, Vol. XXVI., p. 296.

‡ See Sir A. Geikie and J. J. Teall, "On Banded Structure of Gabbros in Skye," *Quart. Journ. Geol. Soc.*, Vol. L., p. 657, and Plate XXVI.

has been, to say the least, intensified during alteration. Modern observation in this matter has supported the views of that master geologist, Charles Darwin, who opposed his opinion to that of Sedgwick, Lyell, and most of the teachers of his day.*

The present tendency is to regard the ancient schists and gneisses as a complex mass of formerly molten materials, which have successively intruded through one another, and which have been, as a whole, deformed and foliated by subsequent pressures.† Sir A. Geikie suggests that the "overlying graphite-schists, mica-schists, and limestones of the Gairloch and Loch Carron may thus be surviving fragments of the stratified crust into which these deep-seated masses were intruded," the latter masses now forming the Lewisian gneiss of Scotland.

In almost every area of ancient gneissic and schistose rocks, there is found a series of true sediments, deposited across the worn-down edges of the foliation-planes, but still earlier than the fauna known as Cambrian. Examples are the Huronian deposits of North America, and the little-altered Torridon sandstones that form the bulwark of western Sutherland. The occurrence of fragments of the fundamental rocks in this overlying series shows that the essential structures of the old complex gneissic group had been impressed upon it long before Cambrian times. Prof. Bonney‡ is so struck by this fact that he regards the banding of the gneisses as due to conditions which have not repeated themselves since ordinary sediments began to be deposited upon the globe. Whether we adopt his view, or the more rigidly uniformitarian one of Sir Archibald Geikie, we must see in the complex floor of schists and gneisses the oldest rocks accessible to us in the earth's crust. For our present purposes they are "fundamental."

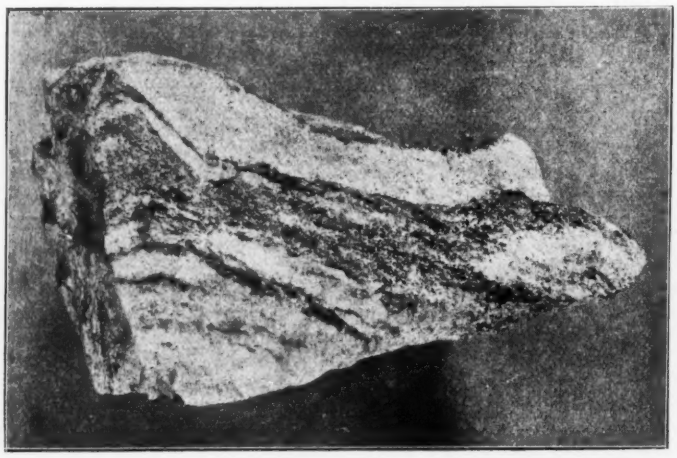


FIG. 1.—Block of Gneiss, twenty centimetres long, from Co. Mayo, showing (i.) curving upper surface formed by fracture along a foliation-plane; (ii.) dissimilar materials in different bands, the lighter ones consisting of quartz and felspar, and the darker ones being rich in dark mica; (iii.) a lenticular mass at the right-hand end, with the darker layers flowing round it.

Yet the upper boundary of the fundamental gneiss presents difficulties when it comes to be surveyed in detail. At times, subsequent pressures have obliterated the discordances between the gneissic surface and the overlying stratified deposits; the great earth-mill has rolled all these rocks out together, and has produced a community of structure, and even an appearance of continuity.§ So that there is little wonder that the older geologists saw a complete passage from sediments into schists, and from schists into gneisses, and urged that gneiss was the ultimate stage of the alteration of ordinary sediments.

At other times the fundamental gneissic mass is found to send off dykes and veins into the overlying rocks, which we have hitherto regarded as being far younger than the gneiss. Sometimes these appearances may be due to the intrusion of a granite through both series, its close resemblance to the gneisses allowing it to lie among them undetected. But another solution has been offered, which presents us with a new aspect of the continental floor. Mr. Joseph Nolan,* in 1879, suggested that granitic intrusions might arise from the depression and remelting of an ancient metamorphic series. This series would remain for the most part "fundamental"; but its offshoots would, of course, be later in age—*i.e.*, in date of consolidation—than the rocks invaded by them. Prof. A. C. Lawson† has attributed much of the structure of the Laurentian gneisses of Canada to this second period of flow, and has provided us with excellent photographs of gneiss including fragments of the overlying series. Similar phenomena are recorded by Dr. Gregory‡ at the junction between what was regarded as "fundamental gneiss" and the schists of the Western Alps; and the conclusion is arrived at that these central gneisses of the mountain-chain are as recent as Miocene and even Pliocene times. M. Michel-Lévy,§ as is now well known, has proved that the gneiss-granite of Mont Blanc is intrusive in the schists surrounding it; so that here again we fail to recognise the true continental floor in its new guise of an igneous invader. General McMahon,‖ again, sees in the gneissose granite of the Himálayas a rock of late Eocene age, and regards its foliation as the result of pressure acting while it was still a viscid mass. It is doubtful, indeed, if the gneissic cores of mountain-ranges ever represent the oldest rocks of the chain. Probably they have no age but that of the folding of the strata. The complex arch of stratified rocks was formed, and fused material (often derived from the continental floor) was forced into it as it rose.

* "Geological Observations on South America," Minerva Library edition, pp. 439 and 440.

† Compare Sir A. Geikie, "Ancient Volcanoes of the British Isles," Vol. I., p. 117; and C. R. Van Hise, "North American Pre-Cambrian Geology," *Sixteenth Annual Report, U.S. Geol. Survey*, 1895, p. 753.

‡ "The Foundation-Stones of the Earth's Crust," *Nature*, Vol. XXXIX. (1888), p. 92. Compare a very interesting paper on crystalline gneisses, by J. Lomas, F.G.S., *Geol. Magazine*, 1897, p. 537.

§ See Van Hise, *op. cit.*, pp. 730 and 752.

* "Metamorphic and Intrusive Rocks of Tyrone," *Geol. Mag.*, 1879, p. 159.

† "Geology of the Rainy Lake Region," *Geol. Surv. of Canada, Ann. Report*, 1887, pp. 130-140.

‡ "The Waldensian Gneisses and their Place in the Cottian Sequence," *Quart. Journ. Geol. Soc.*, Vol. L., 1894, pp. 235, 261, 279, and 273.

§ *Bull. des Services de la Carte géol. de la France*, No. 9 (1890). See also Gregory, "Geology of Western Alps," *Science Progress*, Vol. III., p. 169.

‖ *Proc. Geol. Assoc.*, Vol. XIV. (1895), p. 93, and *Geol. Mag.*, 1897, p. 304, etc.

If doubt hangs round these masses, which were once thought to be ribs of the primordial earth, but which appear to be often of very modern origin, we may look with more respect upon the fundamental rocks exposed in broader areas. Scandinavia and the north of North America have already been referred to; but bosses of the continental floor appear in many places, entirely surrounded by the deposits of later days. In most of these cases the surrounding areas have subsided, leaving the resisting ribs and pillars of the old crust standing firmly. As the floor of the continent must also have subsided, to allow of the falling in of the upper layers, it is very likely that some contrary upward movement was at the same time given to these bosses and plateaux which now stand above the general level. While subsidence predominated, owing to the contraction of the earth's interior, we may conceive a buckling of the floor, some parts rising as others fell. The sediments slipped into the new hollows from the flanks of the masses across which they once had stretched; so that a series of dislocations (faults) now surrounds the exposed and elevated portions of the floor.

Suess* and Neumayr† have emphasized most strongly the part played by subsidence in bringing the resisting knots of the continental floors to light. The word "horst," used by Suess for a ridge left upstanding between two adjacent areas of subsidence, has become extended so as to include any old mass bounded by faults, along which younger strata have slipped down. Favourite examples are found in the Black Forest and the Vosges, which are bold highland areas composed mainly of "fundamental" rocks. The Feldberg in the former still rises 4901 feet above the sea, and the Hoheneck near Gérardmer gives us 4580 feet. On the north-east we have to cross the Danube to the Bavarian forest, and on the south-west we must reach the central plateau of France, to find the compeers of these high irregular masses.

In the uplands of Bohemia we find a wide exposure of the floor of Europe, giving us a strange undulating granite land. Every hollow is set with lakelets, beside which the villages are placed. One may travel day after day across the plateau, at heights of eleven hundred to thirteen hundred feet above the sea. Now one ascends a gentle swelling upland, but the towers of the town in the next hollow can already be descried across the ridge. The descent is thus similarly gentle; and the broad surface of the ancient rocks is only occasionally broken by a valley.

The central plateau of France presents very different features. It is far more broken, far more cut into; and portions of it, rising above the general level, are covered with heather, and seem to form independent moorland ranges. But, when we enter fairly on it, we soon recognise the old uniform surface of the plateau, though hundreds of streams have carved deep hollows, into which we descend from time to time. Thus, in the western portion of the plateau, we cross river after river running to the Atlantic, notably the lordly Vienne at Limoges, the Briance among the mountains of Pierre-Buffière, the Vézère at the foot of the steep street of Uzerche, and many other minor streams, until we drop from the rim of these antique highlands into the great valley of the Corrèze. The roads are carried, however, as far as possible along the ridges between adjacent valleys; we catch no glimpse of the streams until we actually cross them, lost as they are in the deep brown cuts that they have made; and looking across country from one high-perched village to another, the upper surface seems wonderfully level — a plateau undisturbed by structural lines. It is as if we could sweep Sutherland clear of the Torridon sandstone and other stratified masses, the rubbish heaps of the early days of denudation, and reveal the still older floor of fundamental gneiss and granite upon which these strata were laid down.

FIG. 2.—Ridge of Ancient Rocks, seen from Church Stretton, Shropshire, showing their prominence in the landscape. (From a photograph by Mr. J. J. Cole, F.R.A.S.)

Upstanding blocks, then, in some places, vast denuded areas in others, reveal to us, across a continent, the nature of the floor on which it lies. The British Isles, as so often happens, serve us as a model of these larger geological features. If the Outer Hebrides recall to us the worn-down surface of North America, from the great lakes to Hudson's Bay, the hills east of Church Stretton (Fig. 2), the Malvern range, and the little plateau of Charnwood Forest are excellent examples of the "horsts." Formerly these masses were held to be igneous, and later than the rocks through which they now protrude. The patches of old strata upon their flanks were not unnaturally regarded as altered products of the easily recognisable beds on either hand. But more detailed mapping has shown that the floor of Europe is here brought to our notice through the covering of strata that once stretched uniformly from Wales to the eastern counties.* Old ridges, which were buried even in Cambrian times, have reasserted themselves, their horst-like nature being often evidenced by the great faults that can be traced

* "Das Antlitz der Erde," Bd. I. (1883), pp. 167, 265, etc.

† "Erdgeschichte," Bd. I. (1886), pp. 309, 327, 331, etc.

* See, for instance, Geologists' Association, *Record of Excursions*, p. 412.

along their flanks. The fine range of the Malverns—the backbone of the English Midlands—may thus owe much of its pre-eminence to the subsidence of the country to the east, whereby the Trias now forms a lowland which is easily flooded by the Severn; while the Carboniferous rocks, which cause such mountainous country further north, are safely hidden away far below the reach of denudation.

The floor of a continent is, then, a reality—something that supports this wrinkled film of scarps and furrows, of level plains and axial ridges, on which we spend our lives. If we cross a continent and an ocean, we say that we have seen something of the world—much as a fly who should contemplate St. Peter's from the weathered surface of the dome. The true world lies beneath us; and as yet the only certain clue that we possess as to its constitution is its well-determined mean specific gravity. This figure is 5·6, as against 2·6 or 2·7 for the mean specific gravity of the accessible crust. Denser masses than those familiar to us in the crust thus seem to form the great body of our planet; and it is very likely that our continental floors are really portions of the lightest layer on the globe. Processes of denudation, acting on the surface, have separated the constituents of this layer; have collected, for example, the heavy iron-ores at some points, or have formed carbonates and sulphates and hydrous compounds, of various densities, at others; while heavier materials, forced up through fissures from below, have added sheets of basalt or bosses of gabbro to the manifold rocks of the outer film. Nor must we forget that the remelting of the old crust has locally enabled it to absorb masses above it, and has thus increased its mineral complexity. The general mass of the "floor," however, has remained much as it was—a series of granites and gneisses and highly siliceous schists of comparatively low specific gravity.

We must refer in conclusion to Mr. Osmond Fisher's "Physics of the Earth's Crust"* for a discussion of how this light siliceous layer is probably thicker beneath the continents and thinner beneath the oceans. Both the plumb-line and the pendulum tell the same tale. The former should be drawn out of the perpendicular by the attraction of high continental land; and from a survey of the mass of land that stands, in any case, above the level of the sea, the theoretical amount of deflection of the plumb-line can be calculated. But the actual deflection has been found, by experiments in India, to be less than the calculated amount. Archdeacon Pratt, after much labour, arrived at this conclusion; and Sir George Airy, in 1855, pointed out its probable explanation. The attraction of mountain-masses, and consequently of continents as a whole, is deficient, because the light crust is actually thickened beneath them; hence, for every great anticlinal ridge or bulge upon the surface a corresponding ridge or bulge seems to be formed downwards, displacing the more dense and basic matter below. Mountains have "roots," therefore, and tablelands are similarly thickenings of the light outer crust. If there is even a thin liquid layer—to make the smallest demand—beneath the consolidated crust, it is easy to see how lateral pressure in the crust may produce a bulge in two directions, both upwards and downwards. The continental floor, on these grounds, becomes still more real to us, and may be compared to the mass of concrete on which buildings are floated in equilibrium when foundations have to be laid in oozy mud or sand. The formation of these knots in the crust need not be opposed to our view of the instability of continents and ocean-basins; for the lower layers of a continental mass may become melted off, in accordance with Mr. Fisher's own "theory of the earth," while the thinner ocean-floor may become thickened in its turn by compression. Most of us, however, must be content to return from these somewhat speculative regions to the continental floor itself; and in the relations of the rocks that form it, in their mode of consolidation, their interpenetration, and the deformations suffered by them, we shall find absorbing problems for a lifetime.

* Second edition (1889), pp. 124, 195, 204, etc.

ECONOMIC BOTANY.

By John R. Jackson, A.L.S., etc., *Keeper of the Museums, Royal Gardens, Kew.*

INTRODUCTORY.

THE first and by far the most important attempt, in this and perhaps in any other country, to elucidate and make popular the economic side of botanical science was begun by the late Sir W. J. Hooker, when in 1847 one room of the building now known as Museum No. 2 in the Royal Gardens, Kew, was fitted up for the purpose to which it has ever since been devoted.

The foundation and progress of the collections now contained in the three Museum buildings in the Royal Gardens is certainly remarkable. It was in the year just mentioned that the building, which had hitherto been used partly as a storehouse for fruit, "was added by command of Her Majesty to the Botanic Garden proper." The nucleus thus formed consisted of the Director's private collections, presented by himself. To quote from the official guide to the Museums: "No sooner was the establishment and aim of the Museum generally made known than contributions to it poured in from all quarters of the globe, until in a few years the ten rooms of the building, with its passages and corners, were absolutely crammed with specimens. Application was therefore made to Parliament by the Chief Commissioner for a grant to defray the expense of an additional building for the proper accommodation of the objects, and the house occupied by Museum No. 1, opened to the public in the spring of 1857, is the result."

From that time the collections have gone on increasing in importance and value till at the present time they stand unrivalled all the world over. Besides this, in almost every botanic garden at home and abroad, as well as in most teaching centres and in large towns, museums on the system of those so well known at Kew have been established.

The result of all this has been the diffusion of a knowledge of economic botany, so that at the present time the subject is taken up even by our elementary schools, most of which have their own small collections for teaching purposes. It must be confessed, however, that until the last ten or twelve years the subject did not command that attention its great importance deserved. The structure of plants, their affinities, their geographical distribution, and similar points attracted the attention of the scentific worker, who gave no consideration to their properties and uses. The connection, however, between the purely scientific and the economic sides is very apparent upon a moment's consideration. Thus, in some natural orders there is a distinct property running through the plants which constitute the order, which may serve as an indication of their botanical affinities and also prove them to be of economic value or otherwise. Such, for instance, we find in the *Malvaceæ*, where the inner barks for the most part abound in long soft fibres, and the roots and fruits of many are mucilaginous—the roots of the marsh

mallow (*Althæa officinalis*) and the fruits of gombo or ochra (*Hibiscus esculentus*) being illustrations—while in the allied order, *Sterculiaceæ*, the fibrous inner barks are interlaced. Again, in *Gentianeæ* all parts of the plants abound in a bitter principle, which makes them valuable as tonic or febrifugal medicines. Further, some natural orders abound in milky juices, some of which are wholesome while others are poisonous; and others, again, upon solidifying become elastic and form caoutchouc or india-rubber, and in this connection may be mentioned such orders as *Artocarpeæ*, *Euphorbiaceæ*, *Apocynaceæ*, and *Asclepiadeæ*. A knowledge, then, of the properties of the several natural orders, or of any group or genus of plants, is not only of assistance in their determination, but is also of much help in deciding their economic or commercial value. As a proof of this we may give but one illustration. It not unfrequently happens that new oil seeds make their appearance in the Liverpool or London markets, and, being unknown to the brokers, do not find buyers until their botanical affinity is determined, and their harmless or poisonous nature thus known. Serious consequences might otherwise arise if the seeds were allowed to be crushed, and the cake sold for feeding cattle. This is only one example of the importance of a knowledge of economic botany in connection with trade and commerce. That it is a great factor in the development of the resources of the vegetable kingdom all over the world we hope to show in succeeding articles, in which we propose to treat of the principal products in this great kingdom of nature.

FROM A HOLE IN THE MUDFLATS.

By HARRY F. WITHERBY, F.Z.S., M.B.O.U.

IN the months of December, January, and February the mudflats of our tidal rivers are not nearly so attractive to the ornithologist as in the autumn. Then the birds are much more numerous in species if not in numbers, owing to a great influx of migrants staying here and there for a brief visit on their way to the South. Amongst this host of migrants there may always be the chance of picking up a rare bird, and it is this chance, and the variety of the birds, which makes shore-shooting so much more interesting in autumn than in winter. Then, again, unless there is a hard and continuous frost, the birds become much wilder, and therefore much more difficult to obtain as the season advances. For instance, in August, when the young knot, godwit, sanderling, and others have just arrived from the North, they will often allow you to approach them on the open mudflat to within a few yards. In December these same birds will not allow you to come within two hundred or three hundred yards of them in the open. In the winter, therefore (except, as has been said, during a frost), the shore-shooter has to work very hard and resort to many stratagems to obtain the birds he wants.

There are many ways of getting within gunshot of these wary birds. They may be stalked if there is suitable cover, and the birds are near enough to it. This method entails careful marking down, generally a large amount of crawling, absolute silence, and frequent disappointments. The joy of one success, however, will compensate for a dozen failures. Another method is to hide behind a bank or in some suitable place near the high-water mark, and wait for the tide, which, as it advances, drives the birds before it and gradually within range of the hidden gun.

Yet another way, if you know the ground well, and have studied the flights of the birds over the land at high tide, is to lie hid in one of these lines of flight and take your chance of their flying within shot.

It will be easily seen that all these methods are very uncertain, and that their success or failure is influenced greatly by the element of luck.

There is no method known to me in shore-shooting that is certain to be a success, but perhaps the best all-round way of obtaining shore birds in the winter is to dig a hole in the mud, sit in it, and wait. This plan certainly does not appear a very cheerful one at first sight, but to anyone who is a really keen ornithologist it will soon prove a most interesting occupation, notwithstanding the cold, the cramped position, and the slimy mud.*

As many of the readers of KNOWLEDGE have probably never either dug or occupied a hole in the mudflats, a brief description of how it should be done may prove acceptable. I was taught the art by a Yorkshireman, one of the best 'longshore-shooters I have ever known.

Carrying our guns, game bags, field glasses, a long-handled wooden spade, and a bundle of straw, we arrived at the river bank just as the tide was at its lowest ebb. It would be, I think, impossible to successfully dig a hole where the mud is a dead flat, because the mud thrown out of the hole is black, and being scattered about on the brown surface would scare the birds away for a mile round. There is, however, usually on every extensive mudflat a part which is more or less broken up into a wavy sort of formation.

We made our way to an excellent place of this sort about a mile from the shore, where long parallel ridges about three feet wide were separated from each other by troughs full of water. We selected a good wide ridge, flanked on either side by fairly deep ditches, and commenced operations. The bundle of straw was put on the mud, and on it were balanced my friend's gun and game bag, and his coat, for digging a hole in the mud is warm work on the coldest day. First of all a circle was marked out, and then the digging commenced, and the mud as it came out was thrown into the troughs at the side. The mud stuck,

Low Tide.

every now and then, even to the wooden spade, which had to be continually lubricated in the water to make it run

* If the shore-shooter is lucky enough to be living on the spot, he may think it worth while to sink a tub in the flats, and thus make things more comfortable; but few have the chance of doing this.

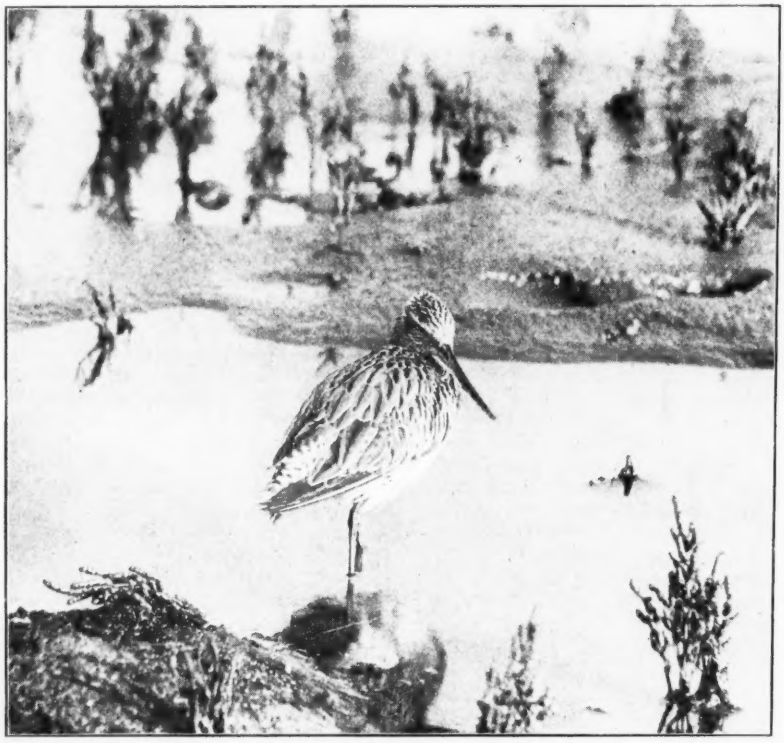
smoothly. Having dug a hole about three feet in diameter and three feet in depth, half the area was dug out another two feet in depth. When this was done, and the straw was put in and arranged round the sides, there was a capital and snug retreat, if a little dirty, with a good seat and plenty of room for the legs.

The hole should be dug to such a depth that when sitting in it the eyes are just above the surface of the mudflat. Of course the shape of the hole can be varied to suit its position. The water will not ooze through the mud, and a well-dug hole will keep quite watertight until the tide flows into it; but sometimes the stratum of mud is not very deep, and when the sand at the bottom is reached the water will immediately come through and soon flood the hole. A shallow oblong hole, of the same depth all over, can easily be made in this case. The plan then is to sit at the bottom and stretch the legs out, but this is a more cramped position than the other, and shooting is consequently made more difficult. Before getting into the hole, great care should be taken in levelling and hiding as far as possible the mud that has been thrown out, and the fewer the footmarks near the hole the better.

Birds, and especially the wading birds, have wonderfully keen eyes, and the slightest elevation or dark spot can be seen at a long distance on a mudflat.

Once seated in the hole the first thing is to make yourself comfortable. If the weather is cold the more straw you have and the thicker your clothes the better. Little "pockets" can be gouged out of the sides of your retreat, and filled with straw, forming convenient receptacles for cartridges and field-glasses. Cartridges should always be handy, because it is not easy to get at coat pockets when crouching in a hole. Next a few little wisps of straw should be stuck here and there round the rim of the hole on which to rest the gun. Great care should be taken over this simple precaution. In the excitement of the moment—say, when a big flock of birds is approaching—the muzzle of the gun is apt to be stuck into the mud, and when the gun is pulled away the barrels are securely "corked." The result is a damaged gun and perhaps a great opportunity missed.

When everything is arranged to your satisfaction you begin to look about you. You have the same view as a bird would have when it is sitting upon the mud—and an extraordinary view it is. Nothing but a flat expanse of mud stretching for miles all round. There is nothing to guide the eye—there is no correct idea of size or distance; a small stake a mile away looks enormous and quite near. There is no living thing to be seen—nothing but miles and miles of mud rolling away to your limited horizon, where the water can now and again be made out as it sparkles in the rays of a winter sun. Suddenly there is a swish of wings behind you, and a little dunlin appears like magic, and settles down within a few yards. Then comes another and another, until there is a small flock of them. Dunlin are silly little birds, and quite unlike the other birds of the mudflats. They never see danger until it is too late to escape. So these birds come and settle down within a few yards of a deadly gun, and, without looking round, immediately begin to feed. Common, tame, confiding, inconspicuous, low-bred little birds, they might appropriately be termed the sparrows of the mudflats. Nevertheless, they are very interesting to watch when they are near, and ignorant of the presence of a human being. They feed very industriously—running up and down the mud, probing with their slender bills here and there, and singing in a soft and pleasing way all the time. Now and again a couple will have a little dispute about some dainty morsel, which results in all sorts of little antics. There is never a stand-up fight, but just a little bickering and pushing and dancing about and the affair is over; one of them gets the tit-bit, and the feeding goes on as peaceably and assiduously as ever. The birds will walk all round you, but sooner or later one comes within a foot of your face, and then suddenly his terrible danger dawns upon him. He is startled out of his life, and flies up with a "tchurr," uttered as though he had a sudden catch in the breath. The others follow suit, and you are once more left in solitude.



The Bar-tailed Godwit. Photographed from Life by R. B. Lodge.

Now is the time to use the field-glasses. Ever so far away there is a huge black mass on the mud—it is a flock of, perhaps, six or eight thousand knot. Although to the naked eye it looked like a great black cloth spread out upon the mud, if you look carefully with the glasses you will see that it is continually moving. Every moment a bird flies up to change its ground, and shows its white under-side,

which looks like a flake of snow against the black mass. Beyond this flock there are a number of large dark objects moving about. By their shape and the manner in which they feed you can tell they are curlew, although they are too far off for you to see their long curved bills.

Five fair-sized birds have risen from the mud and come flying towards you. At first you cannot make them out, but as they come nearer their long and slightly upturned bills and light brown plumage can be seen, and you put them down as godwit. Now, if you are on the east coast it is not every day you will see a godwit in the winter, so you are particularly anxious to get one of these birds. As ill luck will have it they seem to be passing right out of range, so you whistle "whee-whaup-whaup, whee-whaup-whaup." They have heard it and round they come. You keep on whistling and crouch low, and the silly birds come right over your head. Bang! bang! You have got one but missed the other, and you consider yourself lucky that they answered to the call.

Mr. R. B. Lodge, who is well known as a very successful bird photographer, has very kindly allowed me to here reproduce a photograph of a living godwit. When the unapproachable nature of shore birds (on account of their shyness and the want of cover) is taken into consideration, this photograph may be regarded as a triumph of skill and patience. I might here advise Mr. Lodge to try photographing birds from a hole in the mudflats. I feel sure it would prove a success.

After retrieving the godwit, and when you are once again settled down, you find that the tide has been slowly but surely creeping up, and as it comes so it drives in the birds with it. There are usually dunlin, grey plover, ringed plover, and a few other birds (according to the time of year), fairly near the shore even when the tide is right out; but the big flocks of knot, the flocks of duck and geese, the parties of curlew and others, generally feed right at the edge of the water. When the tide was far out, and there were a number of square miles of uncovered mud, it was just a chance if a flock, or a single bird even, came within the limited range of your gun; but now, with the tide well up, the feeding grounds circumscribed, and the flocks on the move, you will have the best chances of the day.

Lucky indeed is the man who, as he crouches in his hole, hears a deafening roar and rush of wings, and looks up to find one of those vast flocks of knot sweeping along, forty yards above his head. It is an impressive sound and a thrilling sight, and neither will be forgotten.

If the hidden gunner is not overpowered by the spectacle, and has the presence of mind to fire, he will pick up a score or two of birds than which none are better eating; but the sight and sound alone will be a rich reward for many hours of cold and dreary waiting.

It is, indeed, rare to be so close to one of these enormous flocks on the wing, but there are other good things that will come to the man who perseveres, even in sitting in a hole on the mudflats.

The curlew—one of the wariest of birds—may be watched at close quarters and brought to bag.

I well remember one winter's day. I had been watching and waiting without success for four hours in a hole which had taken some labour to dig, as more than one blistered finger testified. The tide was rapidly approaching and all chances of sport would soon be over for the day, when eighteen curlews suddenly appeared and settled down within two hundred yards of me. They commenced feeding, and to my disgust I soon saw that they were slowly walking further and further away. As a last resource I began to whistle softly "courlieu cur-cur-courlieu." They heard me and stopped feeding. I whistled louder and louder. They did not seem quite satisfied, but nevertheless they turned and began to slowly walk towards me, feeding as they came. I continued to whistle, and as they got nearer I could see them plainly and watch their every action: the leisurely way they fed—walking along in a stately fashion, and every now and again looking round or stepping aside to probe their long curved beaks up to the very base in the soft mud. Their manner struck me as a great contrast to that of the dunlin, with his dumpy little body, his quick run and eager probing here, there, and everywhere. But I soon began to wish the curlew would walk a little faster. I was becoming tired of whistling, and the tide was getting very near and would soon flood me out. At last one of the curlew was well within range and several more were fairly near. The water began to trickle into the hole, so I jumped up and made sure of the bird nearest to me, but missed with the second barrel. Had I been an older hand I should have done as a friend of mine once did. There was a flock of Brent geese walking towards him. He waited patiently until one of the birds actually came to the edge of the hole, and was naturally surprised to see a man there. The man jumped up and shot a goose a little distance off, and then bowled over the one which had been so near to him, and had by that time flown away about forty yards.

One has to be careful when walking off the mudflats at night. The ridges of mud are slippery and deceptive. I once fell full length into two feet of water, and drove my gun into the mud up to the breech. A friend of mine once stepped into an old hole which was full of water. Luckily, he went in feet first. Had it been head first, it is unlikely that he would have got out again.

A carefully dug hole will last two or three days before it either falls in or becomes silted up. Of course it fills with water and has to be baled out before it can be occupied again, and however dry it is baled it is never so comfortable as a freshly dug one.

In conclusion, let me recommend ornithologists to make a trial of "holeing in the clays." A close acquaintance will be made with a number of very wild birds, and many pleasant hours will be spent studying their ways. Moreover, there is certain to be some sport, and there may be such a chance as comes to the ordinary man but once in a lifetime.

LIQUID FLUORINE.

By C. F. TOWNSEND, F.C.S.

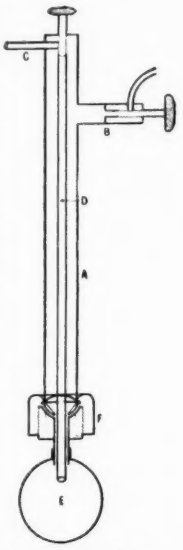
THE alchemists of the middle ages believed that somewhere in the universe was to be found an universal solvent, which would dissolve the most refractory substances as readily as water dissolves sugar. They named their solvent liquor *alkahest*, and what time they could spare from the search after the elixir of life and the philosopher's stone was spent in the endeavour to obtain it. Science has yet to prove, by the way, that there was not more method in the madness of the alchemists than is generally supposed, for in the remarkable substance, fluorine, chemists possess a material that approximates very closely to an universal solvent. Its chemical energy is so fierce that, except gold and platinum, nothing can resist it; and even gold and platinum succumb to fluorine in time. The mere contact of most substances with fluorine is sufficient to cause, not mere solution, but light, flame, and fierce detonations. Dull, inert flint takes fire when exposed to fluorine vapour and becomes a brilliant incandescent mass. Lampblack bursts

into flame, whilst charcoal burns with bright scintillations. Only the diamond is able to resist this powerful solvent, to which it does not succumb even at high temperatures. The similar element, silicon, which can be obtained in a crystalline form closely resembling the diamond, gives a magnificent display in the presence of fluorine, the crystals becoming white-hot and throwing showers of fiery spangles in all directions. The heat is so intense that the crystals melt, showing that their temperature has reached one thousand two hundred degrees Centigrade. Phosphorus combines fiercely with fluorine. Prussian blue, on account of the cyanogen it contains, burns with a beautiful pink flame; whilst from a crystal of iodine placed in fluorine vapour a heavy liquid distils with a pale flame. This liquid—an iodide of fluorine—etches glass, and if thrown into water hisses like hot iron. The last-named metal becomes white hot when exposed to fluorine; even iron-rust behaves in a similar manner. Nearly all metals are raised to vivid incandescence in a current of the gas, many appearing very beautiful, especially aluminium and zinc. If the latter be slightly warmed it bursts into a white flame too dazzling to gaze at or describe.

Although it has been known in various states of combination for many years, having been first discovered by Schwankhardt, of Nuremburg, in 1670, and rediscovered by Scheele in 1771, fluorine was not obtained as fluorine in the free state until about six years ago, when the French chemist, Moissan, succeeded in isolating it by employing a current of electricity from twenty-six or twenty-eight Bunsen batteries. The current was passed through the compound of fluorine and hydrogen known as hydrofluoric acid, which is similar to hydrochloric acid. To improve the conductivity of the hydrofluoric acid it was necessary to dissolve another fluorine compound in the liquid. As will readily be imagined, it is not so difficult to obtain free fluorine as to keep it when obtained. Every part of the apparatus used by M. Moissan was made of platinum, with screw joints and washers of lead, which swell on contact with fluorine; all the stoppers being of fluor-spar. Fluorine has a powerful affinity for silicon, one of the principal constituents of glass, so that it was impossible to use glass vessels or tubes to contain the gas.

As regards the chemical nature of fluorine, it is a gas at ordinary temperatures, and is the lightest member of the series of elements containing chlorine, bromine, and iodine. The attraction of fluorine for hydrogen exceeds that of chlorine, and is so great that if a slow current of fluorine gas be passed into a tube of fluor-spar containing a drop of water, a dark fog is produced, which changes presently to a blue vapour consisting of ozone—the condensed form of oxygen. The last-named substance appears to be one of the few materials which has no affinity for fluorine; nothing is observed to take place between them even when they are heated up to one thousand degrees Fahrenheit.

So far all experiments had been conducted with fluorine gas, which, at the time it was isolated, resisted all attempts to reduce it to the liquid state. Six years ago, however, there was no laboratory—such as that at the Royal Institution—having powerful machinery for producing liquid air or liquid oxygen, at the command of the investigator; in fact, liquid air itself was practically unknown. By the aid of this weapon, Professors Dewar and Moissan have succeeded in liquefying fluorine. At the extremely low temperature of liquid oxygen it was found that fluorine did not attack glass, and it was possible to use glass vessels to hold the newly liquefied element. The apparatus consisted of a small glass bulb, E, fused to a platinum tube, A, which contained another similar smaller tube, D. Each of the platinum inlet and outlet tubes, B and C, was fitted with a screw valve, so arranged that at any moment communication could be cut off, either with the outer air or with the current of fluorine. The whole of the little apparatus was placed in a cylindrical glass vacuum vessel (not shown in the figure) containing liquid oxygen, and connected with a vacuum pump and a manometer. On entering, the fluorine gas passed into the annular space and then down the tube, D, into the glass bulb. At the temperature of boiling liquid oxygen ($-180°$ C.) the gas passed right through the apparatus, but without attacking the glass. As soon as the air pump was worked and the liquid oxygen boiled vigorously, a yellow mobile liquid—fluorine—was seen condensing in the bulb.



Apparatus for Liquefaction of Fluorine. (From the *Proceedings of the Chemical Society*.)

Although at this very low temperature ($-185°$ C.) silicon, boron, carbon, sulphur, phosphorus, and iron, previously cooled in liquid oxygen and placed in the liquid fluorine, remained unattacked, a fragment of frozen benzene or oil of turpentine was acted upon with great vigour, accompanied by incandescence, showing that the great affinity of fluorine for hydrogen still remained.

Professors Moissan and Dewar noticed that if the liquid fluorine came into contact with liquid oxygen two layers were formed, the fluorine being at the bottom. If the oxygen was not quite dry they found that a white flocculent precipitate, which they believe to be an hydrate of fluorine, fell to the bottom. This could be filtered off, and detonated violently as soon as the temperature rose.

From the experiments it was found that the boiling point of fluorine is very close to $-187°$ C., being identical with the boiling point of argon. This appears to be the first example of two gaseous elements boiling at the same temperature.

By boiling the liquid oxygen surrounding the fluorine at a very low pressure by the help of an air pump, the temperature was lowered to $-210°$ C., but the fluorine showed no signs of solidifying. Nevertheless Moissan and Dewar hope to produce a still lower temperature by causing the liquid fluorine itself to boil vigorously at a low pressure.

The specific gravity of liquid fluorine was determined by dropping in small pieces of solid bodies, including wood, caoutchouc, etc., previously cooled in liquid oxygen. It was found that amber rose and fell in the liquid, so that the specific gravity of the liquid fluorine must be about the same as that of amber, namely, 1·14. No specific absorption bands were visible in the spectroscope.

These experiments, which are more than interesting, seem to show that there is no limit to the knowledge (of the material universe at all events) that mankind may hope to secure by patience and increase in mechanical skill, for the work just described has been carried on within sixty-three degrees of absolute zero, where, if our present knowledge is of any worth, the life of the universe itself would be extinguished.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

IS WEATHER AFFECTED BY THE MOON?

To the Editors of KNOWLEDGE.

SIRS,—I have been reading with much interest the article with the above title by Mr. A. B. MacDowall, M.A. There is one difficulty in connecting the barometric curves with the moon's age and position which he appears to have overlooked. It is this. His map of the curves is for London, but taking the meridian of London, and proceeding north or south, the pressure varies greatly on the same day. Thus there may be very high readings in London, whilst very low ones prevail over Scotland and the South of France, or *vice versâ*, according to the position of anti-cyclones or storm centres.

The same may be said regarding places having the same latitude. Storms cross the Atlantic in about a week, though they vary much in their rate of progress and the direction in which the centre of the cyclone advances. May not this be influenced by the increase or decrease of the moon's declination? If this is so, it would help to explain much which is obscure in the way the moon affects the weather.

Near the Equator one would expect to find evidence of any change of pressure caused by the moon's attraction, as twice monthly it passes directly over those regions. This, however, does not seem to be the case. In Southern India the barometer readings scarcely vary for months, excepting the daily tides, and a slight fall during the south-west monsoon.

The spread of this monsoon and the rainfall which accompanies it in Northern India has, I believe, been supposed to be affected by the moon's action, but I do not know on what data. During the monsoon there are usually breaks at intervals of about a fortnight, which would tend to support that theory. L. PAXTON.

Lavant, Chichester.

[I did not overlook the point raised as a difficulty by Colonel Paxton. While I rather think the smoothed Greenwich curve might be taken as fairly representative for a considerable region (perhaps the greater part of these islands), I should not be surprised to find at some more distant stations either (1) an equally good correspondence, but with the waves retarded or advanced somewhat, or even opposite in phase to the Greenwich waves; or (2) a correspondence imperfect or obscured, or no proper correspondence at all. In the former case the evidence of lunar influence would, I consider, be strengthened, and in the latter I do not see that it need be seriously shaken. In a science so little advanced as meteorology, and dealing with such a "complex" of natural causes, we should be extremely chary, I think, about asserting what should or should not happen in this place or that on the hypothesis of some influence of astronomical nature. Our business as students of natural law is primarily with facts, and the interpretation of facts. And in the weather of any region, it seems to me, we may find so large an amount of regular correspondence with some astronomical cycle (that of the moon, *e.g.*), that it becomes more difficult to think all this agreement purely fortuitous than to believe there is a causal nexus between the phenomena. I do not assert it is so in the present case, though I may be inclined to hold it as a "pious opinion." If we find a good correspondence in one region and not in another, may there not be something in the peculiar position of the former region which tends to render the supposed influence apparent? And, similarly, if we find a good correspondence in certain years and not in others, may we not find this due to something special in the relative positions of the moon and the earth in the former case? Colonel Paxton's suggestion that the path of depressions may be influenced by the moon's declination seems to be well worth consideration.—ALEX. B. MACDOWALL.]

To the Editors of KNOWLEDGE.

SIRS,—With reference to the article in your issue for January this year, entitled "Is Weather affected by the Moon?" may I be permitted to make a few remarks? As the writer states, the periods of concurrence between the barometrical curves and the various phases of the moon are irregular; or, to put it otherwise, he sometimes observes that they coincide. *Si post hoc, non ergo propter hoc*, is an excellent maxim in meteorology, as in other things. R. A. Proctor, in an essay called "Sunspot, Storm, and Famine," says as follows: "That for countless ages the moon should have been regarded as the great weather-breeder, shows only how prone men are to recognize in apparent changes the true cause of real changes, and how slight the evidence is upon which they will base laws of association which have no real foundation in fact. . . . And as the weather is always changing, even as the moon is always changing, it must needs happen that from time to time changes of the weather so closely follow on changes in the moon as to suggest that the two orders of changes stand to each other in the relation of cause and effect. Thus rough rules came to be formed; and as (to use Bacon's expression) 'men mark when such rules hit, and never mark when they miss,' a system of weather-lore gradually comes into being which, while in one sense based on facts, has not in reality a particle of true evidence in its favour—every single fact noted for each relation having been contradicted by several unnoted facts opposed to the relation."

Furthermore, I would like to know if pressure alone constitutes weather? G. E. E.

January 16th, 1898.

[While it is well to remind ourselves of the tendency above spoken of, the applicability of Proctor's remarks to the present case may fairly, I think, be doubted. We have to account for a barometric rhythm (similar to the lunar), persisting for the greater part of a year at one time. I have not represented that "pressure alone constitutes weather."—ALEX. B. MACDOWALL.]

VEGETATION OF AUSTRALASIA.

To the Editors of KNOWLEDGE.

SIRS,—It is with some diffidence that I again venture to trespass upon your valuable space, but I can hardly allow Mr. W. B. Hemsley's remarks upon my letter in the September issue of KNOWLEDGE to pass unchallenged. It seems absurd to me—as it must also to anyone who read Mr. Hemsley's article in the May issue of this journal—that he should deny having written the statement I attributed to him, and accuses me of not having read the opening sentence carefully. In this Mr. Hemsley errs, for I read and re-read it, as I could scarcely credit my senses after a first perusal that a botanist of Mr. Hemsley's world wide reputation could be guilty of such a misstatement. Mr. Hemsley twits me with making a general statement *re* the genus *Ficus*, and characterizes it as misleading; it would have been an easy matter to have cited the forty species of this genus, but *cui bono?* If I may make the retort, Mr. Hemsley is still more misleading in his statements. "The Vegetation of Australasia" is the subject of his paper. Queensland forms a large part of

Australia, and Mr. Hemsley now acknowledges that it is much richer in useful plants, and especially in plants yielding edible fruits, than any other part of Australia. Mr. Bailey (and who knows better?) says that Queensland is especially rich in plants of economic value; therefore Mr. Hemsley's general statement that "Australia contains comparatively few plants yielding products of economic value" is misleading on the face of it. It is very like begging the question to say that Queensland contains a relatively large Asiatic element, as distinguished from the characteristic Australian vegetation; this is not the point at all. The plants are in Australia and form part of its flora; their origin in this case matters not. In conclusion I trust Mr. Hemsley will not think I am playing the part of a carping critic, but I must join issue with him once more. His statement that "the aborigines use the bark *thrown off*" from gum trees, etc., for shelter (*ante*, p. 162), is incorrect. The bark thus shed or thrown off is utterly useless for the purpose assigned to it by Mr. Hemsley, being too brittle, very thin, crumbling almost to the touch, curled up by the sun, and only shed in pieces absolutely too small for any practical purpose whatever. The bark used by the aborigines, and by many colonists at the present time, is the true cortex, stripped from the tree by human agency—not nature's. Diagonal cuts are made round the circumference of a tree about a foot or so from its base, and another series of cuts, also round the circumference, about six to eight feet from those below; an incision is then made down the length of the trunk, the bark is tapped gently with an axe on the severed part, and, if the sap is well up, the result is a broad strong sheet of bark peeled right off from round the trunk. Needless to say, this operation kills the tree. I forgot to mention that Mr. Bailey is indeed surprised to hear that the produce of the plants named is known to commerce, and would be pleased to have more information on the point.

Taringa, viâ Brisbane, FRED. WHITTERON.
Queensland, 29th October, 1897.

[As Mr. Whitteron has renewed his accusation that I had stated that "the flora of Australia contains comparatively few plants yielding products of economic value," I will repeat here the opening sentences of my article (KNOWLEDGE, May, 1897, p. 118), which to my mind convey a very different meaning from that portion of a sentence he quoted in his first letter (September, p. 212):—"The popular impression respecting the Australian flora is that it contains comparatively few plants yielding products of economic value, and this is a correct impression so far as edible fruits and vegetables are concerned; but it should be remembered that this is true of most countries. Fruits and vegetables that come to our tables are the result of long generations of cultivation. Take the crab, carrot, parsnip, celery, or almost any of our fruits or vegetables in a wild state, and we should get very little satisfaction out of them. This, however, is a little digression. Australia is by no means poor in vegetable products, and other countries have been greatly enriched by importing and cultivating some of them."

I maintain that the foregoing sentences fairly express the actual facts, and that Mr. Whitteron's wild fruits, with few exceptions, would only be eaten by aborigines or persons in extremities. Returning to the forty species of *Ficus* or fig: Mr. Maiden, in his "Useful Native Plants of Australia," enumerates only three species, two of which he says are used as food by the aborigines; and of the third he cites a traveller who pronounced the fruit "very good," and a writer who states that the fruit is not edible; adding himself that the appetites of explorers frequently become voracious and not too discriminating.

I do not pretend that Mr. Maiden's book is complete and perfect, and I think it is very probable that there are better figs than he was aware of when he wrote. To give another example. In Sir Joseph Banks's recently published "Journal," p. 299, is the following passage:—"We had still fewer fruits; to the southward was one resembling a heart cherry (*Eugenia*), only the stone was soft. It had nothing but a slight acid to recommend it. To the northward we had a kind of very indifferent fig; a fruit we called plums, and another much like a damson, both in appearance and taste. Both these last, however, were so full of a large stone, that eating them was but an unprofitable business. Wild plantains we had also, but so full of seeds that they had little or no pulp."

Here, again, I do not assume that Sir Joseph Banks and his party, with all their knowledge and much as they needed such things, found all or the best the country yielded; but who has read the narratives of the many subsequent explorers in the same and different districts knows how little they found that served to keep body and soul together. Therefore I think the general and qualified manner in which I wrote is fully justified by the facts.—W. BOTTING HEMSLEY.]

EGG COLLECTING IN ITS RELATION TO SCIENCE

To the Editors of KNOWLEDGE.

SIRS,—In connection with Mr. Field's article in your December issue under the above title, I beg to ask the following questions:—(1) Why a light-coloured egg so persistently appears in the clutches of the eggs of some birds and very rarely or never in others? (2) Why are the eggs of some birds coloured at or around the smaller end, whilst those of others are scarcely ever so coloured? Never having accepted the theory that when a light-coloured egg appears in a clutch it is owing to exhaustion of the pigment, I paid considerable attention to this subject in the spring of 1889, taking the blackbird into my confidence.

The following observations, I think, clearly demonstrate that the exhaustion theory cannot be supported by facts:—

March 19th.—Eggs, four; all light in colour; first and third the lightest; all infertile.

March 25th.—Eggs, four; three dark eggs, one light. This brood died in the nest, probably from the cold. One infertile egg.

March 25th.—Eggs, three; the first the lightest coloured egg. All these were fertile.

April 15th.—Eggs, five; four eggs of the normal colour, one very light.

April 15th.—Eggs, five; three dark, two light. In this clutch the lightest coloured eggs weighed one hundred and twenty grains each, the dark ones one hundred and eighteen grains each.

April 20th.—Eggs, three; one egg light in colour; all fertile.

April 20th.—Eggs, five; three dark, two very light.

April 20th.—Eggs, four; three dark, one light.

April 22nd.—Eggs, three; second egg laid the lightest.

April 24th.—Eggs, four; first and fourth light eggs.

April 28th.—Eggs, four; first and fourth light eggs.

May 6th.—Eggs, four; the three first laid light in colour, the fourth darker and very much flecked; this egg infertile.

May 13th.—Eggs, six. In this clutch the first four were typical eggs of the blackbird; the fifth egg very light in colour; the sixth egg dark, and very much coloured at the small end. These eggs were all fertile excepting the fourth, which showed no signs of fertility. This clutch was laid by the same bird, and in the same nest, as the clutch dated March 25th.

The light-coloured eggs are, as a rule, a few grains heavier than the dark, and a dark egg often followed a warm moist day.

Again, in 1890, I watched a nest from day to day and obtained a clutch of five eggs—which I have before me. The first four laid are typical eggs of this bird, but the fifth—the last laid—has a beautiful pale green ground, with flecks and blotches of rich brown. This clutch would be considered by the votaries of the exhaustion theory as a

fine illustration of their theory; but inasmuch as the flecks and blotches are numerous on the pale egg, there must be as much colouring matter on it as on any of the others.

The smaller end marking of eggs is a physiological enigma well worthy of the attention of oologists. This departure from the usual larger end marking is much more frequent among the eggs of the *Falconidæ* and the *Corvidæ* than among those of any other birds; and in looking through a series of twenty clutches of the sparrow-hawk—now before me—I see thirty per cent. of the eggs exhibit this peculiarity. Then, on the other hand, the six hundred clutches of the common house sparrow I have in my cabinet, exhibit less than a dozen examples.

Another question may be asked. Why do two birds of the same genus, namely, the corn bunting and the yellow bunting, oppose and support this style of coloration? I have a very long series of the clutches of both birds before me. In the former there are a very few examples of smaller end marking, whilst in the latter there is a large percentage; and in some of the clutches all the eggs have a circlet of fine lines around the smaller ends, leaving the crown quite bald.

I dare not trespass further upon your space beyond expressing a hope that some of the scientific contributors to your journal may write more fully upon this subject.

Royston, Herts. JOSEPH P. NUNN.

A BRILLIANT METEOR.

To the Editors of KNOWLEDGE.

SIRS,—It may interest you to know that an unusually brilliant meteor was observed from here in *daylight* at 5h. 7m. o'clock, Dublin time, this afternoon. It was seen by several persons. My companion and I saw it first about E.S.E., at a low altitude, perhaps twelve or thirteen degrees above the horizon. It appeared to travel slowly across the sky in an almost horizontal line, slightly inclining earthwards, and disappeared behind a cloud and the hills to the S.E.

The nucleus was very brilliant and large, and was surrounded by a glowing greenish colour; the tail tapered to a point, and was pink along the margins and glowing pale green on the central line. My companion describes the colour as sparkling green. Another observer at a distance from us (of five hundred yards or so) also observed the green colour. Our point of observation was about forty feet above mean sea-level; our view eastwards down the valley was unobstructed. Across the river to the S.E. hills rise about five hundred feet high, and over these some clouds rested; otherwise the sky was clear, and there was *good* daylight. No noise was heard. The wind was about S.W. and light; thermometer 52°.

Carrick-on-Suir, J. ERNEST GRUBB.
Jan. 21, 1898.

DISSOCIATION OF THE ELEMENTS.

To the Editors of KNOWLEDGE.

SIRS,—Dr. Emmens, of New York, has just published a book in which he says that he has obtained a new substance from iron and nickel, and the same substance also from cobalt. He also says that he has converted silver into a substance that cannot be distinguished from gold and which appears to be gold. Is not this an argument in favour of Sir Norman Lockyer's theory with regard to the pre-nebular condition of matter? He describes it as being matter too fine to receive a chemical name, which curdles and produces H. or something allied to H. Further curdling goes on and the dust of Mg., C., O., Fe., Si., and S. is produced, etc., from which I infer that he considers all the so-called elements to be derived from one kind of matter. If the same substance can be obtained from Fe. and Ni., and also Co., does it not appear as if these so-called elements are derived from one and the same kind of matter, or that they are compounds?—which latter is improbable.

Again, if one element can be converted into another, does it not seem probable that each so-called element had one and the same origin? Of course, we know that An. and Ag. belong to the same group of elements, also Co., F., and Ni.; but might not this grouping of the so-called elements point to the same conclusion that they have been built up from the same kind of matter? Might it not also be possible on further investigation to find relations which have not yet been recognized between the different groups of the so-called elements! It appears to me that there is a law, as yet not recognized by chemists, having some connection with temperature, in accordance with which law these so-called elements are built up from one and the same kind of matter. W. H. COCK.

THE BRITISH TRAP-DOOR SPIDER.

To the Editors of KNOWLEDGE.

SIRS,—In connection with the extremely interesting life history of *Atypus piceus sulz.*, the so-called trap-door spider of Britain, by Mr. Fred. Enock, in your November and December, 1897, issues, it may interest some of your readers to know that the Hastings colony is no longer nameless from the want of a mature male. On October 17th, 1897, I accidentally discovered the colony, and on the 31st obtained a mature pair, since determined by the Rev. O. Pickard-Cambridge to be *Atypus piceus sulz.*, the same unfortunately as all the other known colonies in Britain. I have since found several strong colonies in this district, widely distributed, but all *A. piceus*.

52, Tackleway, Hastings. H. G. JEFFERY.

THE URANIA STERNWARTE.

To the Editors of KNOWLEDGE.

SIRS,—I think the following extract will be of some interest to those of your readers who desire to see established, either in the metropolis or in some other large town of England, a similar institution to that now existing at Berlin, viz., the Urania Sternwarte, an institution referred to in KNOWLEDGE for September, 1897. I may add that I came across this extract quite accidentally, shortly after reading Mr. Lavalette's letter on this subject in KNOWLEDGE for August, 1897.

The following is the extract, which was in the *Penny Magazine* for September 25th, 1833.

"PUBLIC OBSERVATORY.—A correspondent, who signs himself 'A Man of Kent,' says: 'Last week, for a shilling, I was able to make acquaintance with an aquatic world whose existence I, till then, had never been aware of. The "hydro-oxygen microscope" convinced me that a dewdrop may be as full of moving beings as Almack's. But I have been all my life, or half my life—that is, all the nights of it—desiring a nearer acquaintance with the stars; and I wish that my honest shilling could procure me admission to some observatory, where I could contemplate those enormous evidences of the Creator's power with as much ease as I did the minute atoms whose existence I had never known of before.' The hint appears to us well worthy the attention of those who have capital and enterprise. We have little doubt that the prevailing desire for knowledge would render a cheap observatory one of the most attractive objects in the metropolis."

If, sixty-four years ago, such an opinion was expressed, how much more now is there need for such an observatory!

Ivo F. H. CARR-GREGG.

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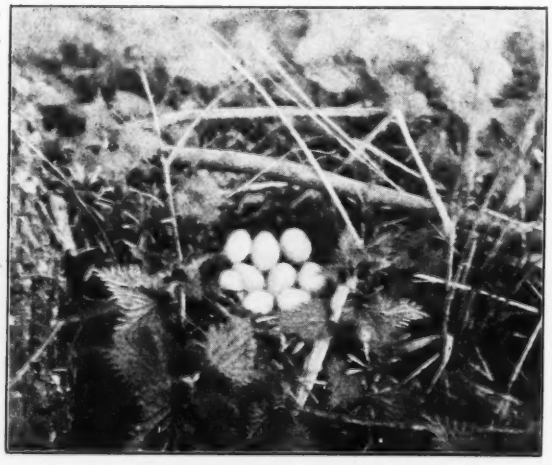
Conducted by Harry F. Witherby, F.Z.S., M.B.O.U.

Wigeon nesting in Yorkshire.—On May 12th, 1897, whilst on a birdnesting expedition in a locality not very far from Scarborough which is largely frequented by waterfowl, I flushed a duck from the ground. A short search sufficed to find the nest—not very carefully concealed amongst some nettles at the foot of a small birch tree. The nest consisted of a hollow in the ground, thickly lined with down from the parent's body, mixed with small pieces of dead nettle stems and dry grass, these latter materials being sparingly used, and conveying the impression that their presence was more or less accidental. The nest contained nine cream-coloured eggs, which I immediately imagined could be no other than Wigeon's; but, being under the impression that this bird did not breed in England, I dismissed the idea as preposterous. As, however, if not a Wigeon's, I could not determine the species to which the nest belonged, I concealed myself, and after a short wait had the pleasure of seeing the parent return, accompanied by the male bird, and was able to see, beyond any doubt, that they were Wigeon. My delight at this unexpected verification of my surmise only an ardent ornithologist can conceive, and I lost no time in getting the camera to work, the result being two pictures—one of which is here reproduced. On June 2nd I was fortunate enough to find a



second nest of the same species, containing nine young ones, near the same place. As the locality was not far from the private lake of a gentleman who keeps a large number of waterfowl of various species, I took the first opportunity of inquiring if there was any probability of the parents having strayed from his place; and was informed that although his birds were pinioned, frequently their progeny escaped in the spring, and that, very possibly, those I had found were some of the home-bred birds. At the same time, during the winter months, the lake and adjacent river are visited by very large numbers of perfectly wild birds, most of which leave in the spring; but it is possible that one or two pairs, attracted by their pinioned companions, suitable surroundings, freedom from molestation, and a plentiful food supply, may have stayed to breed.—Wm. J. Clarke, Scarborough.

[The Wigeon breeds in the North of Scotland, and in a few places in Ireland, but it has never yet been known to breed in a wild state in England. Mr. Clarke's note is of great interest, since it proves that the nest of this bird may now be looked out for in England, with a fair possibility of success. It is unfortunate that semi-domesticated birds were in the vicinity; and taking this into consideration, it is impossible to accept these birds as truly wild ones, and, on this evidence, to add the Wigeon to the birds which breed in England.—H. F. W.]

Hoopoe in Sussex.—An immature female Hoopoe was shot in the Paternoster Wood, Hartfield, Sussex, on December 14th. I cannot find that one has ever been recorded so late in the year before; and as they have been known to breed in the southern counties, is it possible the bird is a native and not a migrant?—Emma L. Turner, December 25th, 1897.

[The Hoopoe occasionally visits us in winter. If the Hoopoe were not so persistently persecuted it would, without doubt, become a regular breeding species in England; but it is never likely to stay here during the winter.—H. F. W.]

Early Nesting of Birds.—An interesting effect of the continued mildness of the weather this season has been the extraordinary fact that several birds have been observed with nests and eggs in December. In the *Field* we find records of Wild Ducks with nests and eggs in the middle of December, and a Robin with a nest and egg on December 16th.

On Hybrids between the Capercailie and the Pheasant. By W. Eagle Clarke (*The Annals of Scottish Natural History*, January, 1898, pp. 17-21).—The fourth example of this curious hybrid is here recorded and described. The bird, which is a male, was obtained in September last at Stronchullin, Blairmore, south-east Argyllshire, where it had been observed for eighteen months, and was sent to Mr. Harvie-Brown by Mr. G. H. Black. The author also describes and gives the history of the other three examples known to science.

Rose-coloured Pastor in West Ross-shire (*Annals of Scottish Natural History*, January, 1898, p. 49).—A bird of this species is recorded by J. A. Fowler as having been obtained on August 16th, 1897, at Inverbroom.

Sabine's Gull in Arran (*Annals of Scottish Natural History*, January, 1898, p. 52).—John Paterson records the capture of an immature specimen of this bird on the shore at Sliddery, Arran, on September 22nd, 1897.

Montagu's Harrier breeding in Ireland.—Correction. (*The Zoologist*, January 15th, 1898, p. 24.)—Mr. John H. Teesdale, who reported the shooting of a specimen of this bird from a party of six in County Kerry (*see* Knowledge, November, 1897, p. 257), now writes to *The Zoologist* that, after further examination, Dr. Sharpe has pronounced the bird to be a young male of the Hen Harrier.

Pectoral Sandpiper in Norfolk. (*The Zoologist*, January, 1898, p. 25.)—An adult female of this species is recorded by J. L. Newman as having been procured on Breydon, Norfolk, on August 18th, 1897.

The Red-crested Pochard (Fuligula rufina) *in Westmoreland* (*Ibis*, January, 1898, p. 176).—The Rev. H. A. Macpherson writes that an immature male of this species was shot in a small tarn in the neighbourhood of Haweswater, Westmoreland, on the 9th of October, 1897.

All contributions to the column, either in the way of notes or photographs, should be forwarded to Harry F. Witherby, *at 1, Eliot Place, Blackheath, Kent.*

Note.—The first issue of Knowledge containing British Ornithological Notes was that for October, 1897.

Science Notes.

A PORTION of a roadway, believed to be of Roman origin, has recently been discovered at Reigate. The path—fourteen feet wide, and five feet below the surface—is composed of flints, the edges of which have been trimmed to fit, and is altogether of a very even character. By some local archæologists the path is considered to be a continuation of the noted Pilgrims' Way to Canterbury Cathedral, which passes through the town of Reigate; while others contend that it formed part of the old Roman road from Winchester to London.

The Council of the Royal Astronomical Society have awarded the Gold Medal of the Society for this year to Mr. W. F. Denning, "for his meteoric observations, his cometary discoveries, and other astronomical work." The medal will be given to Mr. Denning at the annual general meeting of the Society next month.

The Geological Society's medals and funds this year are awarded as follows:—The Wollaston medal to Prof. F. Zirkel, the Murchison medal and part of the fund to Mr. T. F. Jamieson, the Lyell medal and part of the fund to Dr. W. Waagen, the balance of the Wollaston fund to Mr. E. J. Garwood, the balance of the Murchison fund to Miss J. Donald, the balance of the Lyell fund to Mr. Henry Woods and Mr. W. H. Shrubsole, and a part of the balance of the Barlow-Jameson fund to Mr. E. Greenly.

The want of an independent water supply has long been felt at the Zoological Gardens, and recently it was decided to put down an artesian-bored tube well. The results have been, as was anticipated, the tapping of powerful springs of pure water in the chalk, at the depth of four hundred and fifty feet, yielding two hundred and forty thousand gallons per day.

Sir William Gowers, F.R.S., is one of a very few who can trace their success in the world to the accidental influence of shorthand. It was his skill in this art which determined that he should stay in London instead of going into an obscure practice at Bournemouth; it was shorthand which gave him the post of secretary to Sir William Jenner. Those who have been influenced by his books should know that they owe to shorthand every word of them—not one of them would have been written had Sir William been ignorant of shorthand. He contends that that which is secured by the use of shorthand, even at a low speed, is this: in a given time there can be twice the amount of record that is possible with longhand, and yet twice the time in which to observe; and thus transient phenomena can be adequately described which would elude entirely the slow pursuit of longhand. Without the use of writing the facts that pass before him will leave only transient furrows on the sands of unaided memory, vanishing for the most part when new facts disturb the surface; and only immediate record can preserve from these dangers the personal science on which depends the work of those who apply their knowledge to the welfare of the race. It is a prevalent idea that shorthand can be written but cannot be read. On this head Sir William says: "The popular error that it is illegible is due to the immense number of shorthand writers who learn only to write and to immediately transcribe, and who have taken no pains to secure the ability to read. Because reading is not a spontaneous result of writing, it is assumed to be impossible. The ability to read shorthand can indeed be acquired perfectly without any ability to write it, and is sometimes acquired."

Notices of Books.

Light, Visible and Invisible. By Silvanus P. Thompson, D.SC., F.R.S. Illustrated. (Macmillan & Co.) 6s. net. There can only be one opinion upon this book, and that opinion is that the book is excellent in every respect. A course of Christmas lectures at the Royal Institution has to fulfil several conditions, chief among which are: language simple enough to be understood by people who are not engaged in scientific work, experiments numerous and striking, and attention to recent work of importance. Given these conditions and a capable lecturer, and you evidently have the material to construct a work of science at once popular and authoritative. Prof. Silvanus Thompson's book had such an origin, and we have no hesitation in saying that it is one of the best works of its kind ever put before an intellectual public. The student of optics will learn more from it than from half a dozen examinational text-books; the teacher will find inspiration for many instructive experiments; and the general reader whose mind has not been vitiated by indulging in a pabulum of scraps of science will find the whole book a source of mental pleasure. The general facts and principles of the science of light are first described, then the spectrum and the eye, and afterwards follow in succession chapters on polarization, the invisible spectrum (ultra-violet and infra-red parts), the invisible spectrum and Röntgen radiation. The treatment of polarization—a difficult subject to grasp thoroughly—is lucid in the highest degree. The illustrations rank among the best specimens of half-tone process work, and the whole volume is a delightful example of the way in which science should be presented to intelligent readers.

Studies in Psychical Research. By Frank Podmore, M.A. (Kegan Paul & Co.) Before entering on a brief criticism of the contents of this book it is only fair to state that Mr. Podmore deals with his material in what, according to his light, is a perfectly impartial mind. His object throughout appears to be to get at the bottom of the subject, and he sifts the evidence on both sides.

Faith—that's the word—and in it lies the explanation of most spiritualistic phenomena. But it is not given to all of us to see things with an eye of faith, or to be the fortunate percipients of any phenomena which cannot be explained by physical laws or be referred to a derangement of the mental faculties. Mr. Podmore shows that many of the so-called spiritualistic manifestations are due to trickery. Upon a hardened physicist, who has never seen a ghost or heard noises which could not be accounted for physically, who has never been worried in a haunted house or deluded by theosophical revelations, Mr. Podmore's narratives do not make the faintest impression. We learn science through individual experience nowadays, and the results obtained can be tested by anyone who so desires. Is it any wonder, then, that when a set of phenomena which we cannot reproduce at will is brought before us, we are apt to regard it with incredulity?

A number of cases are given of visions received within a few hours of the death of the persons represented. With reference to all of these we say that the evidence is in many cases very weak, and that the accounts of the visions were generally written after the event, whereas they should have been set down before. It is not following a scientific method to select cases when the visions have come true, and leave out of consideration those which have not. Very many people see visions and dream dreams and forget all about them; and we venture to assert that the number of visions and dreams which go unfulfilled far outweigh the few which are afterwards found to have

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some relation to subsequent events. With regard to cases of secondary consciousness, when two distinct individualities are represented in one person, they are due to mental aberration, and furnish subject for inquiry by students of neurology rather than by psychical researchers. Hallucinations of various kinds may also often be found to have their origin in disorders of the optic nerves.

The Reliquary and Illustrated Archæologist. Vol. III. 1897. (Bemrose.) 12s. net. Another annual volume of this luxurious quarterly has been forwarded to us. The illustrations, which constitute the principal attraction, will afford an immense treat to those who delight in antiquarian research. A noteworthy feature is the inclusion of a plate depicting a corner of Chancery Lane as it appeared in the year 1798. We are informed that Isaac Walton lived in one of these houses from 1627 to 1644. The frontispiece is a plate giving a presentment of His Satanic Majesty—the Prince of Darkness—as he is represented at Notre Dame Cathedral, Paris. Other features are no less absorbing; and, of course, the illustrations are accompanied by articles written by experts on the several subjects, the whole forming a most artistic book.

Problems of Nature; Researches and Discoveries by Gustav Jaeger, M.D. Edited and Translated by Henry G. Schlichter, D.SC. (Williams & Norgate.) This selection from the papers of Dr. Jaeger—better known by his hygienic clothing than for his scientific work—are worth publication. The papers cover a variety of subjects in zoology, physiology, anthropology, etc.; and though they were first published between twenty and thirty years ago, many of the ideas contained in them have been justified by discoveries made since their appearance. The essays on Darwinian principles reveal a mind familiar with organic life in many aspects, and acute enough to solve some of the problems involved in it. They would have been given additional value if not only the date of publication, but the organ of publication, had been given at the head of each.

SHORT NOTICES.

Practical Physiology. By Alfred F. Blaisdell, M.D. (Ginn & Co.) Illustrated. 5s. Of all works on physiology that we have perused none seem to approach nearer to the ideal text-book than this one. Physiology as a science is usually taught in schools as a mere catalogue of facts, and very little attention is, as a rule, devoted to its usefulness from the hygienic point of view. One may learn all about the heart, brain, and skeleton of the human body, and yet not be a bit wiser as to the way in which diseases of the human subject may be combatted or prevented. Dr. Blaisdell steps into this breach, and supplies abundance of advice for every emergency. Numberless experiments are given, and chapters on accidents and first aids to injured persons are included. The illustrations, two hundred in number, are excellent.

Reform of Chemical and Physical Calculations. By C. J. T. Hanssen. (Spon.) Illustrated. One great drawback in the interest of chemists and physicists for the last hundred years has been the non-uniformity of the standards of calculations adopted by different nationalities. An attempt is here made to minimize this confusion by adopting a method of calculation which avoids long rows of decimal fractions—discordant values attributable to the variation of the acceleration of gravity in different latitudes. The idea is to establish a chemical and physical observatory on the west coast of Italy, and to take as standards the results of observations made there. The international weight of oxygen—a cubic metre of which weighs, at lat. 45°, 1·42909 kg., and at lat. 52°, 1·43003 kg.—at this place comes out to a very simple figure; and as hydrogen is proposed to be the unit adopted, the exact weight of one cubic metre can be ascertained. The author calls places of the same latitude the "circle of international gravity," which will be to chemists and physicists what Greenwich is to astronomers.

The Story of Germ Life—Bacteria. By H. W. Conn. (Newnes.) Illustrated. 1s. We have already noticed other books in this handy series, and this one in particular is welcome, as it deals with an important branch of modern medicine. It aims at imparting a clear and popular account of these low forms of life, and, as the author remarks in his preface, to enlighten the public as to their power of doing good and bad service to mankind. For example, it may interest consumers of the fragrant weed to know that the different flavours of the various grades of tobacco are probably due to fermentation set up in the curing process by different kinds of bacteria. The inclusion of more illustrations would have enhanced the attractiveness of the book.

We have received a copy of the Thornton-Pickard 1898 catalogue. This issue is in no way inferior to previous ones, either in the way in which it is "got up," or in the value and novelty of the matter which it contains. We especially note particulars of a new shutter at a cheaper rate than hitherto, and a five-by-four Amber camera. We doubt not that these instruments will maintain the high standard of excellence set up by this firm.

BOOKS RECEIVED.

Photo-aquatint and Photogravure. By Thomas Huson. (Dawbarn & Ward.) Illustrated.

Status of Birds in the British Isles and in Devonshire. By H. M. Evans. (Brendon & Son, Plymouth.) 1s.

An Illustrated Manual of British Birds—Parts II. and III. By Howard Saunders. (Gurney & Jackson.) Illustrated. 1s. each.

A Treatise on Chemistry. By H. E. Roscoe, F.R.S., and C. Schorlemmer, F.R.S. Vol. II., Metals. Revised Edition. (Macmillan.) Illustrated. 31s. 6d.

First Year of Scientific Knowledge. By Paul Bert. Revised Edition. (Relfe Brothers.) Illustrated.

Ambroise Paré and his Times: 1510-1590. By Stephen Paget. (Putnam's Sons.) Illustrated. 10s. 6d.

Views on Some of the Phenomena of Nature. By James Walker. (Sonnenschein.) 3s. 6d.

John Bright. By C. A. Vince, M.A. (Blackie.) 2s. 6d.

Nature Study in Elementary Schools. By Mrs. Wilson. (Macmillan.) Illustrated. 3s. 6d.

A Trip to Venus. By John Munro. (Jarrold.) 3s. 6d.

Reader's Shakespeare—The Comedies. By David Charles Bell. (Hodder & Stoughton.) 3s. 6d.

What is Life? By Frederick Hovenden. (Chapman & Hall.) Illustrated. 6s.

Notes on Carpentry and Joinery. By Thomas Jay Evans. (Chapman & Hall.) Illustrated. 7s. 6d.

Experimental Work in Chemistry. By E. H. Cook. (Arnold.) Illustrated. 1s. 6d.

The Tutorial Chemistry. Part II., Metals. By G. H. Bailey, D.SC. (Clive.) Illustrated. 3s. 6d.

Geometry for Beginners. By George M. Minchin, M.A. (Clarendon Press.) Illustrated. 1s. 6d.

The Observer's Atlas of the Heavens. By W. Peck, F.R.A.S. (Gall & Inglis.) 21s. net.

TOTAL SOLAR ECLIPSE, JANUARY 22, 1898.

IT is gratifying to learn that those who journeyed to India to observe the eclipse have enjoyed all the opportunities which favourable meteorological conditions can present for the observation of a total solar eclipse, and there is every encouragement to believe that the results of the several expeditions will form a pleasing contrast to the almost universal failure which attended last year's efforts. The sun was gradually blotted out, and a corona of pale silver and blue appeared. As the eclipse reached its zenith the temperature fell rapidly and the atmosphere became perceptibly chilly. The light during the middle of totality was greater than that from the full moon. The spectacle was magnificent, and excited a feeling of awe and astonishment among the beholders—a scene resembling a landscape under a wintry English sun.

The general shape of the sun's corona was like that seen in the eclipses of 1886 and 1896—that is to say, white, downy blooms winging the dark ball of the moon all round its circumference, but larger on each side of the sun's equator than elsewhere. The streamers, the light of which had a thready aspect, extended into space for an apparent distance of four and a half diameters of the moon. The detailed polar structure arranged itself in lines, as iron filings round the poles of a magnet. The

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SPIRAL NEBULA MESSIER 33 TRIANGULI.

By ISAAC ROBERTS, D.Sc., F.R.S.

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exposures made with the kinematograph for corona were successful, but no shadow was observed. The spectrum of the chromosphere and prominences was successfully observed with an opera-glass fitted with a direct vision prism in one of the eyepieces, and the spectrum of the "flash" was photographed with a prismatic camera and with a six-inch telescope. Indeed, all instruments, with the exception of the integrating spectroscope, appear to have responded fully to the most sanguine hopes of their respective manipulators, and we have had what may be called a record eclipse.

Native astrologers had prophesied all kinds of calamities, including a tidal wave at Bombay and the downfall of the British raj. Immense crowds bathed in the waters of the Ganges at Benares, Calcutta, and other centres during the eclipse; the bathers at Back Bay tied Durab grass to their clothes, and put some of it into pickles and preserves, to ensure that they should not be affected by the eclipse. Religious Hindus sat down and counted their beads at the moment of contact, at the same time reciting mantras or prayers, and hymns, and there was general fasting. It is the impression of some of the Hindus that when there was no British raj in India the solar eclipses occurred once in twelve years, and that they are now more frequent on account of the increase of sins and misdeeds. Here and there on the foreshore stood Parsees, zend or avasta in hand, and with their faces turned towards the sun; priests, ever ready to receive alms, ceased their solicitations during the eclipse. Beggars, however, swarmed nearly everywhere, crying for alms for the recovery of the sun from the jaws of the dragon Ráhn.

Mr. E. Walter Maunder, whose well-equipped party was favoured with excellent conditions for observing and photographing, will contribute a detailed account of the eclipse to the April Number of KNOWLEDGE.

PHOTOGRAPH OF THE SPIRAL NEBULA MESSIER 33 TRIANGULI.

By ISAAC ROBERTS, D.SC., F.R.S.

THE annexed photograph of the nebula was taken with the twenty-inch reflector on November 14th, 1895, with an exposure of the plate during 2h. 15m., between sidereal time 1h. 18m. and 3h. 33m. A previous photograph of the object was taken with an exposure of three hours, on 27th November, 1891.

Scale of the photograph, one millimètre to twenty-four seconds of arc.

Co-ordinates of the fiducial stars marked with dots, for the epoch 1900.

Star (.)	D.M.	No. 256	Zone 29°	R.A. 1h. 26m.	8·8s.	Dec. N.	30°	6·5′	Mag.		
„ (..)	„	260	„	„ 1h. 28m.	1·3s.	„	29°	53·6′	„	8·0	
„ (·.·)	„	265	„	„ 1h. 29m.	38·5s.	„	30°	9·3′	„	9·2	
„ (::)	„	246	„ 30°	„ 1h. 29m.	49·4s.	„	30°	47·6′	„	8·4	

The nebula is referred to in the N.G.C. No. 598, G.C. 352, h 131, and is figured in the *Philosophical Transactions*, 1850, Plate XXXVI., Fig. 5, and in 1861, Plate XXXVI., Fig. 10, and in the "Observations of Nebulæ and Clusters of Stars," p. 20, where Lord Rosse describes its spiral character, which he was the first to detect.

This nebula is one of the many that cannot be adequately described by words, or delineated by eye and hand-work, because of its very complicated, tortuous, and ill-defined structure as seen with a telescope; but the annexed photograph, and, better still, the original negative, enable us to see the remarkable contortions, and the nebulous and star-like condensations, of which the nebula is formed. We can also see the relationship of its parts and their connection in the formation of the object as a whole, so that much of the mystery concerning it, previously to the revelation by the photograph, is removed.

It will be seen that there are two large, very prominent, spiral arms, with their respective external curvatures facing north and south, and that the curves are approximately symmetrical from their extremities to their point of junction at the centre of revolution, where there is a nebulous star of about tenth magnitude, with dense nebulosity, elongated in north and south directions surrounding it. Involved in this nebulosity are three bright and several faint nebulous stars; the two arms are crowded with well-defined and with faint nebulous stars, having nebulosity between them; and it is to the combined effect of these that the defined forms of the arms are due.

Besides these two arms there are subsidiary arms, less well defined, which are constituted of interrupted streams of faint stars and of nebulosity intermingled together. Many of these stars are nebulous, and many are well defined at their margins, but small. The interspaces between the convolutions of the spiral are more or less filled with faint nebulosity, having curves, rifts, fields, and lanes, without apparent nebulosity in them. They are like the interspaces in clouds of smoke, and cannot be classified.

There are outliers of nebulosity with many small well-defined stars as well as nebulous stars involved in them, and there are also isolated nebulous stars on the extreme boundaries of the nebula; the evidence is strong that they are all related to the nebula.

These descriptions, and more, can be verified by examination of the photograph and the negatives; and they arouse in us the desire to know the kind of cataclysm —for such it appears to have been—that produced the general smash and redistribution of the pre-existing matter. Was it the collision of two suns (with or without attendant satellites) in space, moving from opposite directions, with the high velocities known to exist, and smashing each other so that the material of which they were composed was scattered in a thin discoid form of a mixture of meteorites, meteoric dust, and nebulosity? Was it a collision between two swarms of meteorites, or of two clouds of nebulous matter, or of one of each kind?—for we know with certainty that both forms of matter (meteoric and nebulous) are common in space, and that they extend over areas of sufficient magnitude to include this nebula—or is there another more probable cause?

We may with considerable confidence draw inferences as to the future development of the nebula, for it is evidently aggregating into stars; and those aggregations are assuming the various lines and curves that we can trace in the finished stars which are strewn over the sky.

This nebula is not an isolated example of its class which has been revealed by the aid of photography. There are, for instance, the great nebula in *Andromeda*, Messier 101 *Ursæ Majoris*, and 74 *Piscium* resembling it, though the two last named are further advanced in symmetrical development than M 33; but it is not a tax on the imagination, when the respective photographs are compared with each other, to satisfy our sense of sight that the construction of these four nebulæ has resulted from similar causes, and that their developments into curves and lines of stars are proceeding on identically similar principles.

We have as yet no guide to enable us to form an opinion concerning the rate of their progressive development, for the intervals of from four to eight years that have elapsed since the first and second duplicates of the photographs of

XUM

these objects were taken, are insufficient to show sensible changes that may have taken place in their structures; but ere long such changes will inevitably be perceptible, and the photographs will with certainty reveal their extent and character.

Who can say that a catastrophe, such as may have produced any one of these nebulæ, will not occur in our time, and that we shall not be both eye-witnesses as well as recorders of the beginning of another new spiral nebula, in addition to the convincing evidence furnished by those already published, showing the evolution of new stellar systems by processes of disintegration and re-aggregation?

MOON IN ECLIPSE, JANUARY 7, 1898.

ON last Friday night I was watching the eclipse of the moon, and was struck with the density of the penumbra, which prevented the outline of the earth's shadow being distinguished. The penumbra also seemed irregular in shape. As the night was fairly clear I took a photograph with a twelve and a-half inch Calver's reflector, with one of Browning's Kellner eyepieces. Time of exposure, one and a-half seconds. L. PAXTON.

THE SPECTRA OF BRIGHT STARS.*

By E. WALTER MAUNDER, F.R.A.S.

THERE is no branch of spectroscopy without its charm, but the study of the spectra of stars has an attraction all its own. Their likenesses and their differences are so suggestive; they hint at so much of revelation as to the secrets of world life; they have, like an inscription in unfamiliar characters and in an unknown tongue, so plainly a message to tell if we could but interpret them. At such interpretation we have indeed made our first attempts: the riddle is not all unread; we have spelled out a word—it may be even a sentence—here and there, and, like Cleopatra's soothsayer, can say:

> "In Nature's infinite book of secrecy
> A little I can read."

A little as yet; still our knowledge grows, and the fullest putting together of the starry hieroglyphs, the completest alphabet yet formed from them, has just been laid before us.

This work, like so much in the same department of astronomy that has preceded it, comes to us from the Harvard College Observatory, and from that section of it which the munificence of Mrs. Henry Draper has enabled Prof. Pickering to develop.

The great Draper Catalogue was the result of a survey of all stars down to the eighth magnitude, but the dispersion employed was necessarily small, and only the most salient features of the different spectra were brought out. Volume XXVIII., Part I., of the "Annals of the Observatory" continues the photographic study of stellar spectra, giving, however, but six hundred and eighty-one stars as compared with the ten thousand of the Draper Catalogue; but these have been photographed on so much fuller a scale that our advance in the knowledge of stellar constitution will owe far more to it—and one cannot, indeed, help regretting that the more special discussion had not preceded the more general.

The present survey is based upon examination of some four thousand eight hundred photographs, representing the spectra of six hundred and eighty-one of the brightest stars north of −30° declination. The instrument used was a telescope of eleven inches aperture and a focal length of one hundred and fifty-three inches, used in connection with objective prisms in number one to four, each of which had a refracting angle of about 15°. The faintest stars could, of course, be only photographed with one prism; the brighter were therefore photographed not only with the highest dispersion they would bear, but in a number of cases with one or two prisms for the sake of better comparison with the fainter stars. The solar spectrum was photographed for comparison with the same telescope, combined with the Draper fifteen-inch reflector used as a collimator.

The detailed study of these spectra and their classification has been the work of one lady, Miss Antonia Maury, and has occupied her nine years. The most considerable part of this great work is therefore hers alone, though the taking of the photographs, a large part of the determination of the wave-lengths, and of the preparation of the volume for publication, fell to other members of the staff.

A glance at Miss Maury's classification shows how great an advance we owe to her. Secchi's types gave us but a view of the most salient differences existing between the stars. Vogel elaborated these considerably, and introduced the important idea of a connection between the type and the temperature of a star. His idea therefore gave us a connected evolution along a single straight line. Lockyer's classification was more elaborate, and was a further advance—at least in so far that he introduced the idea of rising as well as of falling temperature, and gave us for his line of evolution not a single straight line, but a

* "Annals of the Astronomical Observatory of Harvard College," Vol. XXVIII. Part I.—Spectra of Bright Stars photographed with the 11-inch Draper Telescope as a part of the Henry Draper Memorial, and discussed by Antonia C. Maury, under the direction of Edward C. Pickering, Director of the Observatory, Cambridge, Mass. (John Wilson & Sons, University Press. 1897.)

curve, with ascending and descending branches. Miss Maury's investigation goes further still. Her classification lies not in one dimension but in two, and she finds it necessary to divide the spectra she has examined, not only into "groups," forming a nearly continuous series, from spectra bearing a close resemblance to those of the bright-line nebulæ, on to the long-period variables at the extreme end of the series, but also into "divisions," in which the leading idea is not the substances producing the lines but the character of the lines themselves.

It is, of course, extremely unlikely that in this new classification we have arrived at finality, any more than in the classifications which preceded it. But this new factor which Miss Maury has brought to light in the course of her most patient study will certainly have to be reckoned with in the future.

The first division in Miss Maury's scheme—Division *a*—is by far the largest, including three hundred and fifty-five stars out of the total six hundred and eighty-one. In these spectra none of the single lines are relatively wide except those of hydrogen and calcium, and all the lines are "clear"—that is, they stand in distinct contrast to the bright portions of the spectrum. Division *b* comprises stars in the spectra of which all the lines are relatively wide and hazy. The fainter lines therefore tend to disappear, and in consequence those observed are relatively few; but their relative intensity remains much the same as in Division *a*, so that there does not appear to be a radical difference of constitution between the two divisions.

Division *c* is in general distinguished by the strongly defined character of its lines, by the presence of certain lines apparently not found in the solar spectrum, by a difference in the relative intensities of the lines as compared with the solar spectrum; and, further, the lines of hydrogen are narrow and well defined but less intense than in the other divisions, whilst the calcium lines are more intense. Stars of this division, therefore, would seem to differ more in constitution from those of Division *a* than do those of Division *b*.

Besides these three great divisions there are a large number of intermediate forms, whilst quite one-sixth of the total number of spectra cannot be assigned with certainty to any of these divisions, either on account of the faintness of the star or of the imperfection of the photograph.

The cross division into "groups" is less novel than the one just noted into "divisions." Miss Maury's scheme makes the "groups" twenty-four in number. Of these, the first five are those in which the Orion lines are specially prominent—a large number of the Orion lines being now, of course, known to be those of helium. The sixth group is intermediate between the Orion type and Secchi's first type. The full members of this Secchi's first type are divided into five groups according to the intensity of the hydrogen lines, which are at their maximum in Group VII. and decrease later, and to that of the solar and calcium lines, which increase from group to group. The twelfth group comprises spectra between the first and second types, and the full members of Secchi's second type are divided into four groups with respect to the increase of the solar and calcium lines. The third type is distributed over the next four groups, bands and flutings replacing lines. As a necessary consequence the divisional differences are no longer noted; indeed, no spectra of Division *b* are noted later than Group XII., or of Division *c* later than Group XIV. The twenty-first and twenty-second groups correspond to Secchi's fourth type and Pickering's fifth type respectively. There remain, then, two classes unnumbered: the "composite" stars, which are probably doubles of different spectra apparently single from their extreme closeness, and bright-line stars of the Orion type.

The annexed little table, the eighth in Miss Maury's Memoir, brings out in a singularly clear fashion the continuity of the series into which she has thus arranged the spectra in her hand. It will be observed that it is no theoretic succession; it is based upon the actual character of the spectra as the photographs present them, and is perfectly independent of any explanation which may be offered as to the cause of the differences thus scheduled. The succession may be one of temperature, of stage of development, or of actual chemical constitution, and it might be supposed to run in either direction without in the slightest degree invalidating the classification here given. On the subject of theory Miss Maury touches lightly, but points out the close resemblance between Group I. and that of Pickering's fifth type stars, Group XXII., and that the latter connect us with the bright-line nebulæ. This consideration, taken in connection with the fact of the obvious connection of the Orion type stars with the nebular regions of Orion and the Pleiades, strongly supports the view that the groups are numbered from I. to XX. in their true evolutionary order.

Group XXI., however, stands apart from this evolution.

TABLE VIII.—RELATIVE INTENSITIES OF LINES.

Group.	Intensity of Hydrogen.	Intensity of Orion Lines.	Intensity of Solar Lines.	Intensity of K Line.
II.	20	148	1	2
III.	35	162	1	1
IV.	45	151	2	3
V.	90	51	3	4
VI.	100	36	43	6
VII.	100	5	99	8
VIII.	95	1	164	13
IX.	95	1	...	28
X.	90	1	...	58
XI.	60	1	...	83
XII.	25	1	432	135
XIII.	20	0	...	160
XIV.	16	0	568	160
XV.	9	0	712	200
XVI.	7	0	...	200?
XVII.	7	0	...	200?
XVIII.	6	0	860	170?

For Miss Maury finds the difficulty of including the fourth type stars in any regular progression which others have found before her, and which Vogel and Lockyer have tried to meet by such different expedients; the former placing the third and fourth type stars as alternative forms for a late stage in stellar life history, the latter regarding Type III. as indicating an early stage in a star of rising temperature, and Type IV. as a late stage in a star of falling temperature.

It is sufficiently clear from these very different classifications that no very sure foundation for determining the course of a star's evolution has yet been laid down; but it seems to me that in placing the long-period variables at the end of her series Miss Maury has been guided by a true appreciation of the facts before her, and that her scheme therein is a vital improvement on that of Lockyer. And to leave the carbon stars, the fourth type, unplaced, is probably, in the present state of our knowledge, to exercise a wise discretion, though Mr. McClean's photographs of 152 Schjellerup appear to confirm Vogel's suggestion that both Types III. and IV. succeed Type II., but as alternatives to each other.

The connection between the divisions is a more difficult matter, and except possibly in one point it has to stand

without explanation at present. The facts, too, that these divisional differences are practically traceable only amongst the Orion stars and those of Secchi's first type, and that no stars are found of Division *c* in Group XIV., whilst seven are recorded as being intermediate between Divisions *a* and *c*, point to the classification in this direction being neither so perfect, nor so directly the effect of simple causes, as the cross arrangement into groups.

An interesting relationship, which Miss Maury mentions, suggests that in the case of Divisions *a* and *b* the differences between them may possibly be of a mechanical nature rather than one of temperature or constitution. She points out that the two spectroscopic binaries ζ Ursæ Majoris and β Aurigæ, though really of Division *a*, appear as members of Division *b* at that particular point of their orbit when the relative motion in the line of sight of the two members of the system is sufficient to widen the lines of their composite spectrum, but not to separate them into pairs. It is clear, therefore, that the existence of a large number of close binaries might explain the occurrence of Division *b* spectra, provided that these several pairs were composed of stars not very unequal in magnitude, of the same type of spectrum, and with relative motion in the line of sight such that their lines were widened but not separated.

We already know, by direct observation, of binary systems in which the periods vary from five and a half years up to many centuries. The Algol variables and the spectroscopic doubles have similarly revealed to us the existence of systems with periods ranging from a few hours to a few weeks. We may be perfectly assured that there are other systems with periods of an order intermediate between these, not of weeks or of years, but of months. And such, under the special conditions mentioned above, would give us *b* division spectra. In cases where the two components were of different types we should have a "composite" spectrum. It is possible, therefore, that Division *b* and "composite" stars are but different presentments of the same relationship—a binary system of two not unequal stars far too close for optical resolution.

The researches of Darwin on tidal evolution, and of See on that of double stars, lead us to the conclusion, since double stars tend to widen with age, that these very close binaries are yet in an early epoch of their life history. The fact, therefore, that the Algol stars and those of Division *b* are most plentiful in the Orion and first type groups is a confirmation of Miss Maury's conclusion that these are early forms of spectra, and seems better to accord with the facts than Lockyer's view, which places the Sirian stars midway in the evolution.

The test, of course, of the truth of the suggestion will be that a prolonged watch of Division *b* spectra will sooner or later show in some instances a gradual change into Division *a*.

It is worth remembering that there may be a yet earlier stage of double star evolution: where we have a single star in rapid rotation, the separation into two distinct bodies not having as yet taken place. Such rapid rotation would produce a widening and a haziness of the lines—a "Division *b*" spectrum, though differing in character from that of the close binaries. This would not be periodic in its character, and so not demonstrate itself by the test just mentioned.

Division *c* stands on a different footing, and appears to point to a real difference of constitution. The stars, however, of this division are so few in number that the progress of the groups cannot be followed out with anything like the distinctness of Division *a*.

Annexed is a copy of Miss Maury's Table I., which shows at a glance how the stars observed are distributed amongst the various groups and divisions. The numbers in the first column refer to Secchi's types: *O* designating Orion stars, *C* composite spectra, *L* bright-line stars. The last column gives the grouping of the Draper Catalogue. Under the heading "Division" the sub-heads *ac* and *ab* indicate forms intermediate between Divisions *a* and *c* and *a* and *b* respectively; the sub-headings *a*, *b*, and *ab*, *ac* signify spectra which cannot certainly be assigned to either division, owing to the faintness of the star or the imperfections of the photographs. Peculiar spectra are ranged under the sub-head *P*.

Classification of Spectra.

Type.	Group.	Division.								Total.	D.C.
		c.	*ac.*	*a.*	*a, b.*	*ab.*	*b.*	*ab, ac.*	*P.*		
O	I.	...	...	...	...	...	7	...	...	7	B
O	II.	...	...	4	5	...	5	...	2	16	B
O	III.	1	...	5	7	...	5	...	1	19	B
O	IV.	...	...	11	22	3	14	...	...	50	B
O	V.	3	...	9	8	...	5	...	...	25	AB
O-I.	VI.	6	...	4	9	3	9	...	...	31	AB
I.	VII.	1	...	13	13	...	17	...	1	45	A
I.	VIII.	1	1	23	6	3	17	...	7	58	A
I.	IX.	...	...	?	17	3	9	5	...	34	AF
I.	X.	...	...	2	12	2	3	...	...	19	AF
I.	XI.	...	5	?	11	5	...	7	1	29	F
I.-II	XII.	2	3	29	...	1	...	...	...	35	FG
II.	XIII.	4	1	22	...	...	...	...	...	27	G
II.	XIV.	...	7	40	...	...	...	...	3	50	G
II.	XV.	...	...	117	...	..	...	...	1	118	K
II.	XVI.	...	...	23	...	...	...	...	...	23	K
III.	XVII.	...	...	19	...	...	...	...	...	19	Ma
III.	XVIII.	...	...	20	...	...	...	...	...	20	Mb
III.	XIX.	...	...	10	...	...	...	...	...	10	Mb
III.	XX.	...	...	4	...	...	...	...	2	6	Md
IV.	XXI.	...	...	...	...	...	...	...	...	4	Na
V.	XXII.	...	...	...	..	...	...	...	...	4	O
C.	—	...	...	...	..	...	...	...	...	18	—
L.	—	...	...	...	..	...	...	...	...	14	—
Totals	..	18	17	355	110	20	91	12	18	681	

Beside the two tables given above, very complete tables are supplied of the wave-lengths of the lines found in the different classes of spectra, Fomalhaut being taken as the representative of the first type stars, and the star H.P. 1311 for the fifth type. The solar lines are catalogued from the D lines of sodium to the line ρ of hydrogen far in the ultra-violet, and the lines of Division *c* stars from β to κ of the hydrogen series of lines. The complete catalogue of the 681 stars arranged in order of R.A. is supplemented by tables in which they are arranged in order of spectral group, and copious notes add much important information as to the details of individual spectra, whilst a minute description of the classification, group by group, occupies the longest chapter in the work.

In view of Prof. Ramsay's striking discovery of helium, one naturally looks eagerly to find the place accorded to that spectrum in this classification. The work was, however, too far advanced at the time when the helium spectrum was revealed to us for it to be taken account of in the actual classification. All that could be done was to add a supplementary note. In this we are given a table in which the helium lines are compared with those of the Orion stars, and are told that all the series of both helium and parhelium are represented in them. It appears, further, that nearly all the lines of the first subordinate series of both helium and parhelium are very strong in

Group III., and reach a maximum in Group IV., and fall off far more rapidly toward the later groups than toward the earlier. It is important also that they are more clear and conspicuous in Division *c* than in Division *a*, and far more persistent—the lines 4471·65 and 3819·75 being present in Group VIII., Division *c*.

Complete and thorough as the Memoir is in every other respect, it is impossible to escape the regret that it was not accompanied by a well-chosen series of photographs of typical spectra. We feel sure that if these could have been supplied, they would have added greatly to the value of Miss Maury's careful descriptions and to the information which is to be derived from them.

Great as is the evident value of this Memoir, it may be taken as certain that we shall not be able to realize how heavy a debt we owe to Prof. E. C. Pickering and Miss Maury until it has been made the basis of the many researches which will inevitably be founded upon it. Nine years may seem a long time to have devoted to such an inquiry, but the more the Memoir is studied the more one will feel surprise, not that it has taken so long to prepare, but that so much has been so quickly accomplished.

ANCIENT RED DEER ANTLERS.

By R. LYDEKKER, B.A., F.R.S.

WHATEVER may be the case with regard to its applicability to the human race, there can be no question that the phrase, "There were giants in those days," is perfectly true when the antlers of modern red deer are compared with those of animals living a few centuries ago on the Continent, or with the specimens that are from time to time dug up from the fens of Lincolnshire and Cambridgeshire, or from the bogs of Ireland. Not only are such ancient specimens much larger in respect of length and girth of beam than any to be met with at the present day, but they also greatly exceed the latter in respect to the number of tines or points they carry, as also in the complexity of the so-called cup in which the crown or summit of the beam so frequently terminates. At the time the big antlers of the English fens and Irish bogs crowned the heads of living animals, both Britain and Ireland were either still connected with the Continent, or their separation therefrom was an event of comparatively recent occurrence; and as the greater part of the country was still clothed with forest, the deer were able to wander about as much as they pleased, and there was nothing to prevent them attaining the maximum development of which the species was capable. And on the Continent the conditions of life were, if possible, still more favourable. Contrast this with the mode of life of the deer of the Scottish highlands at the present day. The so-called "deer forests" are nothing but open moorland; and as red deer are naturally forest-dwelling animals, this alone is sufficient to account for their relatively small size and the small development of their antlers. When to this is added the comparatively small size of the area on which they are located, coupled with the effects of more or less continuous in-and-in breeding, it is but small wonder that the antlers of even the finest of Scotch deer are but poor things when compared with those of their predecessors. Some of our readers may perhaps be disposed to say that this is due to the circumstance of the deer being shot down at too early an age, before time has been allowed them to perfect the full growth of their antlers, and that if they were allowed to enjoy life a few years longer their trophies would be fully equal to those of a past age. But, as a matter of fact, this is not the case. After a certain age the antlers of deer begin to retrograde or degenerate, when they develop fewer points than at the prime of the animal, and not unfrequently display various abnormalities. And as Scotch red deer are frequently killed with degenerating antlers, it is manifest that this is not the cause of the comparatively small size of these appendages. Such a degenerating head, showing certain abnormalities, is represented in our first illustration. Like the other specimens figured, this example is in the collection of the Viscount Powerscourt, at Powerscourt, County Wicklow, and belonged to a very aged animal. Its history is somewhat curious. The stag was killed by poachers in Ross-shire during the year 1844, and by them given to Mr. Hay Mackenzie, father of the late Duchess of Sutherland. By her Grace it was presented to Frederick, fourth Marquis of Londonderry, by whom, in turn, it was given to Lord Powerscourt in 1857.

FIG. 1.—Skull and Antlers of Aged Scotch Red Deer.

FIG. 2.—Antlers of Red Deer from an Irish Bog.

English park red deer, from their more congenial surroundings and richer pasture, develop finer antlers than those of their wild Scotch cousins, but even these bear no comparison to those of the stags of former ages. Although larger antlers are still obtained on the Continent, these are—for the most part, at any rate—inferior to those killed years ago. It is true that in the Carpathians and Caucasus magnificent heads are still fairly common. But these belong to a variety known as the Maral or Caspian red deer, in which the face is longer than in the typical race of Western Europe, and the coat more or less distinctly spotted with white in summer, while, as a rule, the crown

of the antler is less distinctly cupped and carries fewer points. Still, it is very difficult in many instances to distinguish the antlers of the two races, which, in certain districts of the Austrian Empire, probably pass imperceptibly into one another.

This inferior development of modern red deer antlers being then a well-ascertained fact, it is a matter of congratulation that there exist a few collections where the trophies of the ancient giants have been accumulated and preserved almost from time immemorial, or where judicious purchase has assembled a series which it would be almost, if not quite, impossible to rival at the present day. Of collections of the former kind, by far the finest is the one belonging to His Majesty the King of Saxony, at the old hunting schloss of Moritzburg, near Dresden. Of the latter type, so far as the United Kingdom is concerned, the celebrated collection of Viscount Powerscourt, already mentioned, is far and away ahead of all others. By the kindness of the owner, the present writer has been favoured with photographs of a series of the finest specimens in this collection, from among which a few have been selected to illustrate the present article.

Fig. 3.—Antlers of Ancient German Red Deer, purchased in Berlin in 1863.

From the great individual variation displayed in a large series, the uninitiated often find considerable difficulty in distinguishing the antlers of red deer (including under this term the different races thereof) from those of the allied species. Nevertheless, after some practice, this is a comparatively easy matter; and the subject is one of considerable interest, on account of showing, in spite of great individual variation, the adherence to one distinctive type of structure. The red deer and its allies form a small and well-defined group of the genus *Cervus*, among which are included the wapitis of North America and Central and North-Eastern Asia, the hangul of Kashmir and Yarkand, and the great shou of the district lying to the northward of Bhutan. In all these deer the minimum number of tines to each antler is five, but there may be as many as twelve, or even more. A very general and especial peculiarity of the group is the presence of two tines on each side in close proximity to the forehead. The presence of these two tines is, indeed, as a normal feature, limited to the members of this group, and even among them it is by no means invariably constant. There is, for instance, a Tibetan species, known as Thorold's stag, in which the second is wanting, and the so-called brow-tine alone remains in this part of the antler. The presence of this second tine in the red deer group is clearly, then, what naturalists term a specialized feature of comparatively recent acquisition. And further testimony in favour of this is afforded by the circumstance that even in well-developed heads this tine is frequently much smaller on one side than on the other. This is shown in Fig. 2, where the second tine on the right side is scarcely more than half the length of its fellow on the left. Even more significant is the fact that in heads which are degenerating—or, as sportsmen say, "going back"—this tine is the first to disappear, or to diminish in size. An excellent example of this is afforded by the head represented in Fig. 1, where it is completely wanting on the right side, and is small and rudimentary on the left. Indeed, among Scotch deer the second tine is very frequently wanting even during the prime of life, thus affording further evidence of the decadence of that stock. It is also wanting in the small island race of Corsica and Sardinia, as it is very frequently in the larger race inhabiting the North of Africa and Spain. The red deer being typically a northern species, the degeneracy in the latter instance is probably due to the warmer and therefore less suitable climate.

At some distance above the second is given off a large third tine, which is quite distinct from those above it. In fully developed heads of the red deer of Western Europe, as exemplified by Figs. 2 and 3, the beam of the antler continues undivided for an interval somewhat exceeding the one between the second and third tines, after which it expands to form a more or less distinctly defined cup whose margins are bordered by a variable number of snags or tines of different length. In heads of this type it is scarcely possible to distinguish a separate fourth tine. Nevertheless, in heads where the cupping is less conspicuously developed, the fourth tine exists as a separate portion of the antler, the cupping being then confined to the termination of the beam above. This type of antler is shown by the German head depicted in Fig. 4; and it may be noted that in the Carpathian race of the species it is common to find the fourth tine remaining more or less distinct, as it does in the degenerate modern Scotch deer. The shape of the cupping varies considerably in different individuals, as may be seen by comparing the old German head represented in Fig. 3 with the one from an

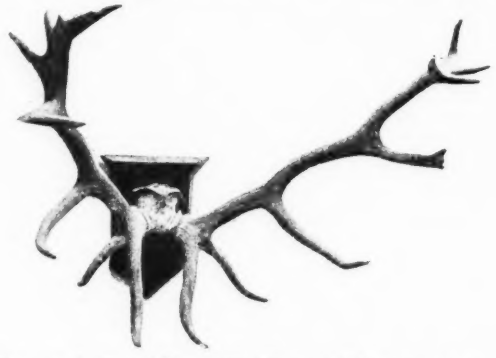


Fig. 4.—Antlers of German Red Deer with Twenty Points.

Irish bog which forms the subject of Fig. 2; the former showing a total of eighteen and the latter of nineteen points. Considerable individual diversity also exists with regard to the angle at which the antlers are set on the forehead. For instance, in Fig. 2 they are directed much upwardly, and this is still more markedly the case with Fig. 3; but as the latter specimen consists of separate antlers affixed to an artificial head, the degree of inclination is not altogether to be depended on. The subject of Fig. 5, which is also an ancient German head, is, however, in its original condition, and here it will be noted that the degree of divergence is very great. This head, too, is

remarkable for the number of its points, which reach a total of twenty-two; and the almost complete absorption of the fourth tine in the terminal cup-like expansion is also a feature which can scarcely fail to attract attention. Two-and-twenty is, however, by no means the maximum of points, as a pair of antlers from an Irish bog, formerly

FIG. 5.—Antlers of Ancient German Red Deer with Twenty-two Points.

in the collection of the late Sir Philip Egerton, but now in the British Museum, carry no less than thirty. And it must not be supposed that modern Scotch stags never make an approach to such high numbers, a specimen shot some years ago by Lord Burton exhibiting a total of twenty.

In spite of the individual variations alluded to, the form of the fourth tine and the terminal cup affords an easy means of distinguishing the red deer antler from that of the wapiti, whether American or Asiatic. In the latter the fourth tine always forms a huge forwardly projecting prong, much larger than either of the three tines below, and situated in the same fore-and-aft plane as the tines above, which are normally quite distinct from one another, and thus do not form a terminal cup. Occasionally, however, such a cup is formed even in wapiti antlers; and it is said that in certain districts of America such cupped antlers are by no means uncommon, being apparently hereditary. Even in such instances, however, an experienced eye will have no difficulty in picking out the wapiti antler, for the great fourth tine always retains more or less of its characteristic form and size, and the whole antler is thus quite unlike that of any red deer.

It has already been said that the red deer of Eastern Europe usually have the terminal cup less developed than in the old giant race of the more westerly districts; and, as we proceed further to the north-east in Asia, the antlers of all the nearest relatives of this species tend to become simpler still. For instance, in the hangul, or Kashmir stag, the number of points on each side rarely exceeds six or seven; while in the still larger shou, of the country to the north of Bhutan, they are limited to five a side, no trace of a terminal cup being formed. Clearly, then, the group attained the culminating complexity of antler development in the countries of Western Europe; and whether this complexity would have gone on increasing to an almost indefinite degree had not man appeared on the scene, and checked the further evolution of these and most other animals, may afford an interesting subject of speculation to the curious. Equal room for speculation exists as to the purpose of the great complexity exhibited by the antlers of the red deer. As fighting weapons, the huge but simpler horns of the shou would seem to be at least equally efficacious; and to human taste it is by no means certain that their severer simplicity of form is not more graceful than the many-branched red deer horn. But it by no means follows that human and cervine æstheticism run on the same lines; and if antler development be due to female preference for the stags with the finest horns, a *vera causa* may exist in this direction.

All the different variations of red deer antlers alluded to above are of a more or less strictly normal type, but there are other variations less commonly met with which come under the designation of abnormalities, or monstrosities. And although such attract much attention from sportsmen and amateurs, the scientific naturalist, as a rule, has no more to do with them than he has with two-headed pigs or three-legged chickens. Nevertheless, there may be exceptions even to this general rule, and a case in point seems to be afforded by a peculiar head of a French red deer in the Powerscourt collection, which forms the subject of Fig. 6. From this figure it will be seen that the left antler is of normal form, exhibiting the first, second, and third tines, and a rather small terminal cup, of which the fourth tine forms a constituent part. The right antler, on the contrary, is double from base to summit, and of a much simpler structure, each portion consisting solely of a long unbranched beam, with a brow-tine at the base, and a simple four-pointed cup-like expansion at the crown. Now at first sight there might seem nothing particularly noteworthy in this, for in all cases of such duplication the divided antler is of a simpler type than the ordinary undivided one. But the curious feature in this instance is that the duplicated antlers are of the same general type as certain peculiar antlers of the Eastern race of the red deer frequently met with in the Crimea and Asia Minor. And although these latter are undoubtedly to a certain extent abnormalities, yet from their comparative frequency in the districts in question they scarcely come under the designation of monstrosities. Whether the undoubted resemblance existing between the duplicated French antler and these abnormal Eastern specimens is anything more than a coincidence, the facts at our disposal are not sufficient to admit of determining. At any rate, the point is of sufficient interest to merit mention. A similar duplication of one antler—and, curiously enough, on the same side—has been recorded in the fallow deer; and Lord Powerscourt also possesses a second French red deer head in which the right antler is bifurcated for half its length. Probably the circumstance that the abnormality in all these three instances is on the right side is a mere coincidence. It would, however, be matter of some little interest if it could be ascertained whether such malformations are due to any injury received by the animal previous to the growth of the horns.

FIG. 6.—Antlers of French Red Deer, with Duplication on the Right Side.

XUM

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

COMETS.—Pons-Winnecke's comet was detected by Mr. C. D. Perrine at the Lick Observatory on January 1st, when it was described as very feebly visible. It may well have appeared faint, seeing that its distance from the earth was more than one hundred and sixty million miles. Presumably the comet was picked up with the thirty-six inch refractor; but as the object is rapidly approaching the earth, and gaining in apparent brilliancy, much smaller telescopes will now have the capacity to reveal it. Hillebrand's elements for the comet are :—

Epoch	March 15th, 1898.
M	359° 3′ 52·0″
π	274° 14′ 39·0″
$\aleph$	100° 53′ 11·5″
ι	16° 59′ 33·8″
ϕ	45° 37′ 14·1″
μ	608″·5559

Ephemeris for Berlin, midnight.

	R.A. H.	M.	S.		Dec.	
Feb. 10th	18	8	30	...	12°	29·3′
12th	18	18	35	...	12°	47·8′
14th	18	28	48	...	13°	5·1′
16th	18	39	6	...	13°	21·0′
18th	18	49	28	...	13°	35·4′
20th	18	59	56	...	13°	48·2′

On February 1st the comet's distance will have decreased to about one hundred and thirty-three million miles, and it will be visible before sunrise in the southern region of Ophiuchus. The moon sets on the morning of February 1st at 4.15, and the comet may possibly be picked up about two degrees north of the star 47 Ophiuchi (magnitude 6·3).

Perrine's comet (*b* 1897, discovered October 16th) and D'Arrest's comet have become too faint to be observable in ordinary telescopes. The former was seen on November 18th and 23rd, 1897, with a sixteen-inch refractor, at Northfield, Minn., as a very faint elliptical glow, three minutes long and one minute wide, without any perceptible condensation, and so feeble that the slightest illumination of the micrometer wires overpowered it. Three sets of elements have been published, as follows :—

	Payne and Young.	Perrine.	Möller.
T ...	1897, Dec. 8·9216 G.M.T.	Dec. 8·8471.	Dec. 8·6899.
ω ...	66° 10′ 11″	66° 5′ 42″	65° 56′ 34″
Ω ...	32° 4′ 9″	32° 4′ 5″	32° 3′ 27″
ι ...	69° 37′ 21″	69° 37′ 41″	69° 36′ 36″
log. q.	0·13186	0·13206	0·13242

In *Ast. Nach.*, 3471, Herr Bidschof gives some computations with regard to the ensuing return of the comet (Tempel, 1866, I.) of the November meteors. He supplies a sweeping ephemeris, from which it appears the comet will probably traverse Aries in March and April, Taurus in May and June, Gemini in July and August, and enter Cancer at the middle of September. The great distance of the comet and the uncertainty attaching to its precise position, will, however, prevent its being seen. In the summer and autumn of 1898 the comet and earth will rapidly approach each other, and the former may possibly be rediscovered in the winter following.

METEORS.—*The Leonids of 1897.*—Herr A. A. Nyland, of Utrecht, reports that on November 13th he watched the sky from 12h. 51m. to 16h. 7m., and saw twelve meteors, of which seven were Leonids and three Taurids. November 14th was cloudy. On November 15th observations were made between 13h. 8m. and 16h. 45h., and forty meteors were recorded, including thirty-two Leonids. There was a well-defined radiant at 152° + 24° and a secondary position at 150° + 29°; no less than ten very bright Leonids were observed, five being estimated to equal first magnitude stars, one equal to Jupiter, and four equal to Venus. Fifteen of the Leonids left bright streaks. The larger meteors exhibited an orange colour in five cases, and a green hue in four cases.

At the Radcliffe Observatory, Oxford, Messrs. Wickham and Robinson maintained a watch on November 13th from 11h. 15m. to 17h. 45m. There were occasional clouds and moonlight was troublesome, so that during the night only about forty meteors were seen. The nights of November 14th and 15th were cloudy.

Prof. A. S. Herschel, at Slough, observed about ten meteors and no certain Leonids on November 13th, during an extended watch of about seven hours between 9h. 30m. and 18h. The sky was overcast on November 14th.

Sir W. J. Herschel and Mr. J. C. W. Herschel, at Littlemore, near Oxford, on the night of November 13th, between 12h. 30m. and 16h. 15m., counted twenty-one meteors, including about seven Leonids.

Herr Franz, at the Observatory at Breslau, on November 13th, saw six meteors (three Leonids); and on November 14th before 16h. recorded twenty-one meteors, including fourteen Leonids, from a radiant at about 145° + 25°.

Herr Rigginbach, at Basel, on November 13th, between 12h. 30m. and 14h. 30m., counted nineteen meteors (ten Leonids). The following nights were cloudy.

The number of bright Leonids observed by Nyland on the morning of November 16th indicates that, had the sky been favourable before sunrise on November 15th, the shower was, probably, a conspicuous one. Herr Franz's observations on the morning of November 15th terminated at 4h. (= G.M.T. 2h. 52m. A.M.), and before the maximum occurred.

Two of the meteors seen by Sir W. J. Herschel and Mr. J. C. W. Herschel, near Oxford, were also recorded by Messrs. Wickham and Robinson, at the Radcliffe Observatory, Oxford, and by Mr. W. E. Besley at Walthamstow. The meteors were of the first magnitude. One appearing on November 13th, 15h. 28m., was a *Cancrid*, descending from one hundred and twenty-five to seventy-seven miles over the North Sea to Halesworth, in Suffolk. The other was a true Leonid, appearing at 15h. 52m., and falling from one hundred and three to fifty-nine miles over the Strait of Dover to Cranbrook, in Kent.

The Geminids.—Moonlight greatly interfered with observations of this shower. Mr. E. N. Cullum, of Whitby, reports, however, that meteors were both numerous and brilliant on the evening of December 12th. He recorded ten between 8h. and 9h., and many others were seen afterwards. They were nearly all Geminids.

During the past autumn an unusually large number of fireballs have been observed. In the majority of cases, however, the observations were not sufficiently precise and complete to allow real paths to be computed. Three splendid meteors, appearing at convenient times in the evening, were widely observed, and from a large number of descriptions I worked out the following results :—

REAL PATHS OF THREE FIREBALLS, 1897.

Date and hour	(1) October 22nd. 6h. 23m.	(2) Dec. 9th. 9h. 47m.	(3) December 12th. 8h. 6m.
Brightness	... ♀	... ¼ ☽	... ¼ ☽
Height at beginning	59 miles	76 miles	112 miles
Position over	Wooler, Northumberland	Aldeburgh	Lat. 54° N., long. 1° 28′ E.
Height at ending	35 miles	21 miles	19 miles
Position over	Lat. 55° 10′ N., long. 2° E.	Royston	North of Thirsk
Earth point	North Sea	Ampthill	Richmond, Yorks.
Real length of path	171 miles	90 miles	151 miles
Velocity	Very slow	Rather swift	25 miles per second
Radiant point	218° + 10°	113° + 32°	80° + 23°
Inclination of meteor's descent	8°	38°	38°
Parent system	ζ Boötids	Geminids	ζ Taurids

In February no special showers are due, but large meteors are often observed on about the 7th and 10th. At this period there is a well-defined shower from 74° + 43°, near α Aurigæ, which needs further watching.

THE FACE OF THE SKY FOR FEBRUARY.

By HERBERT SADLER, F.R.A.S.

A FEW, but not many or large, spots are visible on the Sun's disc.

Conveniently observable minima of Algol occur at 10h. 13m. P.M. on the **9th**, at 7h. 2m. P.M. on the **12th**, and at 3h. 7m. A.M. on the **27th**.

Mercury is a morning star, but is badly placed for observation on account of his considerable southern declination. On the **1st** he rises at 6h. 27m. A.M., or about one hour and a quarter before the Sun, with a southern declination of 21° 48′, and an apparent diameter of $6\frac{1}{2}''$. On the **10th** he rises at 6h. 36m. A.M., with a southern declination at noon of 21° 8′, and an apparent diameter of $5\frac{1}{2}''$. On the **20th** he rises at 6h. 40m. A.M., with a southern declination at noon of 18° 25′, and an apparent diameter of $5\frac{1}{4}''$. After this he is too near the Sun to be conveniently observed. He describes a direct path while visible through a portion of Sagittarius into Capricornus. He is in conjunction with Mars at 6h. P.M. on the **11th**, but of course both planets will have set.

Venus is in superior conjunction with the Sun on the **15th**, and Mars is practically invisible.

Ceres is still fairly well placed for observation, southing on the **1st** at 9h. 5m. P.M., with a northern declination of 29° 29′, and a stellar magnitude of about $7\frac{1}{2}$. On the **14th** she souths at 8h. 10m. P.M., with a northern declination of 29° 46′. On the **28th** she souths at about 7h. 15m. P.M., with a northern declination of 29° 58′. During the month she describes a short looped path in Auriga.

Jupiter is now very well situated for observation, rising as he does on the **1st** at 10h. P.M., with a southern declination at noon of 2° 42′, and an apparent equatorial diameter of 41″. On the **10th** he rises at 9h. 22m. P.M., with a southern declination of 2° 31′, and an apparent equatorial diameter of 42″. On the **20th** he rises at 8h. 40m. P.M., with a southern declination of 2° 13′, and an apparent equatorial diameter of 43″. On the **28th** he rises at 8h. 2m. P.M., with a southern declination of 1° 55′, and an apparent equatorial diameter of $43\frac{1}{2}''$. During the month he pursues a retrograde path in Virgo, being about $1\frac{1}{2}°$ south of γ Virginis towards the middle of the month, the two objects forming a fine naked-eye double star.

Saturn and Uranus do not rise till some time after midnight at the end of February.

Neptune is still favourably situated for observation. He rises on the **1st** at 2h. 29m. P.M., with a northern declination of 21° 42′, and an apparent diameter of $2\frac{1}{2}''$. On the **10th** he rises at 1h. 40m. P.M., with a northern declination of 21° 42′. On the **20th** he rises at 0h. 54m. P.M., with a northern declination of 21° 42′. On the **28th** he rises at 0h. 28m. P.M., with a northern declination of 21° 43′. He is nearly stationary in Taurus during the month, in a region barren of naked-eye stars.

There are no well-marked showers of shooting stars in February.

The Moon is full at 6h. 24m. P.M. on the **6th**; enters her last quarter at 0h. 35m. A.M. on the **14th**; is new at 7h. 41m. P.M. on the **20th**; and enters her last quarter at 11h. 13m. A.M. on the **28th**. No bright star is occulted at any convenient hour for the amateur observer in February.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of January Puzzles.

No. 1.

1. R to Kt7, dis. ch., K moves. 2. P × B, becoming a Black Knight, dis. ch., Kt to B2, dis. ch., mate.

No. 2.

1. P × R, becoming a Black Rook, Castles! (*a*) 2. R to QB5, B to Ksq, mate.

(*a*) This is a fresh Rook, and evidently, therefore, has not moved. The Black King has not moved (by hypothesis), so that Black is perfectly justified in Castling.

No. 3.

1. P to K8, becoming a Black Knight, ch.

[Both sides being mated simultaneously, the game seems a fair draw. Any other move, such as R to B8, would lose.]

We regret that all the above have proved either unattractive, or, from their novelty, perhaps, too difficult for our solvers.

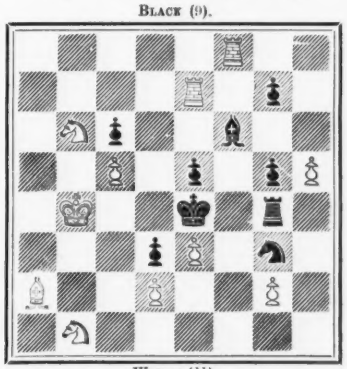
F. W. A. de Tabeck.—The "Chess Intelligence" is intended to be a permanent record of chess events. In a monthly magazine it is obvious that it cannot usually be news. The publication of problems has, during the last nine years, resulted in many hundreds of solutions and inquiries. For some years an annotated game was printed regularly in every number. During all this time there was not one particle of evidence to show that these games were ever played through. We are glad to hear of the exception, and shall endeavour in future to consider the undoubted rights of the minority.

PROBLEMS.

No. 1.

By W. Clugston (Belfast).

BLACK (9).



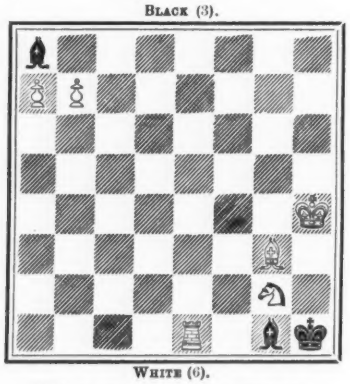
WHITE (11).

White mates in two moves.

No. 2.

By S. Loyd.

BLACK (3).



WHITE (6).

White mates in three moves.

Game played in the Hastings International Tourney.

Queen's Gambit declined.

WHITE. (H. N. Pillsbury.)	BLACK. (A. Burn.)
1. P to Q4	1. P to Q4
2. P to QB4	2. P to K3
3. QKt to B3	3. KKt to B3
4. B to Kt5 (*a*)	4. B to K2 (*b*)
5. P to K3	5. Castles
6. KKt to B3	6. P to QKt3
7. R to Bsq	7. B to Kt2
8. P × P (*c*)	8. Kt × P
9. B × B	9. Q × B
10. Kt × Kt	10. B × Kt
11. B to Q3	11. R to Bsq (*d*)
12. P to K4	12. B to Kt2 (*e*)
13. Castles	13. Kt to Q2
14. Q to K2	14. P to QR3 (*f*)
15. R to QB3	15. P to QB3
16. KR to QBsq	16. P to QKt4
17. Q to K3 (*g*)	17. R to B2
18. Q to B4	18. QR to Bsq
19. P to K5	19. P to QB4 (*h*)
20. B × Pch	20. K × B
21. Kt to Kt5ch	21. K to Ktsq
22. R to R3 (*i*)	22. Q to Ksq
23. Q to R4	23. K to Bsq
24. Kt to R7ch	24. K to Ktsq
25. Kt to B6ch	25. K to Bsq
26. Kt × Q	26. K × Kt
27. Q to Kt5	27. P × P
28. R to R8ch	28. Resigns (*j*)

NOTES.

(*a*) This and the next four moves constitute Mr. Pillsbury's favourite development. It was probably originated by Mr. Steinitz.

(*b*) Best; though there is a well-known trap by 4. . . . QKt to Q2; 5. P × P, P × P; 6. Kt × P, Kt × Kt; 7. B × Q. B to Kt5ch, etc.

(*c*) The logical reply to the Queen's Fianchetto. If Black retakes with the Pawn, White takes the free diagonal with 8. BQ3, retaining command of the QB file, while the Black QB is blocked. If, as here, he retakes with the Knight, White gains time afterwards by P to K4.

(*d*) Obviously, if 11. . . . B × P, 12. P to QKt3, Q to Kt5ch, 13. Kt to Q2. The move made is forced, as White threatens to win a Pawn by Q to B2, unless, indeed, he can venture on 11. . . . Q to Kt5ch.

(*e*) If now 12. . . . B × P, 13. Q to R4 wins a piece. Or if 12. . . . Q to Kt5ch, 13. K to K2, B × RP, 14. R to B3, Q × Pch; 15. R to B2, Q to R6; 16. Q to Rsq. We cannot, of course, say for certain if this was Mr. Pillsbury's idea.

(*f*) A wasted move. Black is apparently trying to keep his majority of Pawns on the Queen's side, when it would be safer to free his game by P to QB4. Nevertheless, his plan is sufficiently ingenious and characteristic.

(*g*) With a view to the direct attack on the King which follows.

(*h*) Completely overlooking White's intention. He should play Kt to Bsq.

(*i*) Threatening R to R8ch. If now 27. . . . Kt to Bsq, 28. Q to R4, Kt to Kt3; and White mates in three moves.

(*j*) For if 28. . . . Kt to Bsq, R × Ktch, followed by R × R, wins everything. The whole finish was very pretty and forcible.

CHESS INTELLIGENCE.

The first-class amateur tourney at Llandudno resulted in a win for Mr. A. Burn with the fine score of nine out of ten games played. He lost only to Mr. Bellingham, who took the second prize, Mr. Jones being third. Messrs. Owen, Sherrard, and Gunston were among the unsuccessful competitors.

The Hastings Annual Chess Festival is fixed for January 24th–27th. Besides the leading English masters, M. Janowski is expected to be present.

A telephone match, played on December 18th between the City of London Club and the Yorkshire Chess Association, resulted in a victory for the former team by $5\frac{1}{2}$ games to $2\frac{1}{2}$. On the same day Surrey defeated Kent by 13 games to 7.

The Vienna and St. Petersburg Chess Clubs are playing a match of two games by correspondence.

KNOWLEDGE, PUBLISHED MONTHLY.

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PLATE.—Photographs showing "Reversing Layer" and Coronal Ring.

NOTICES.

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